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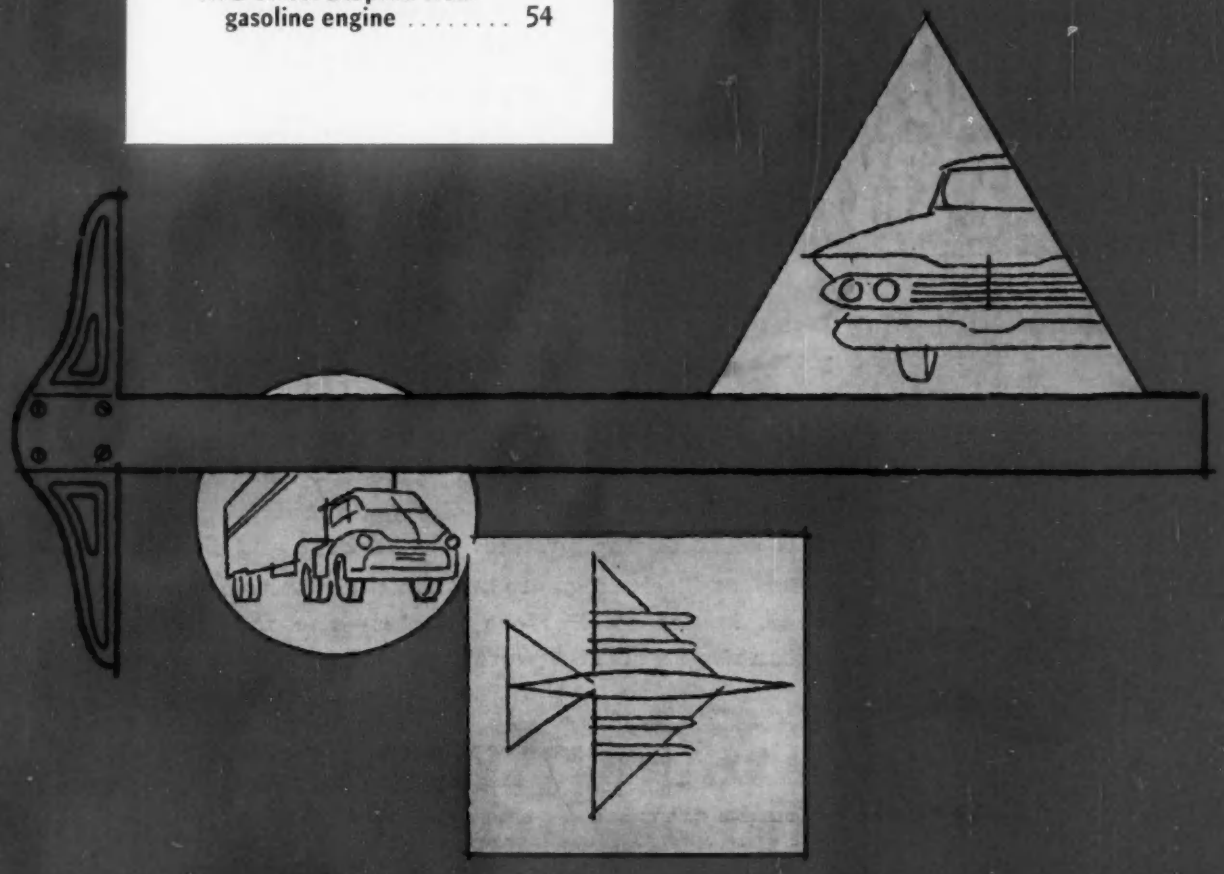

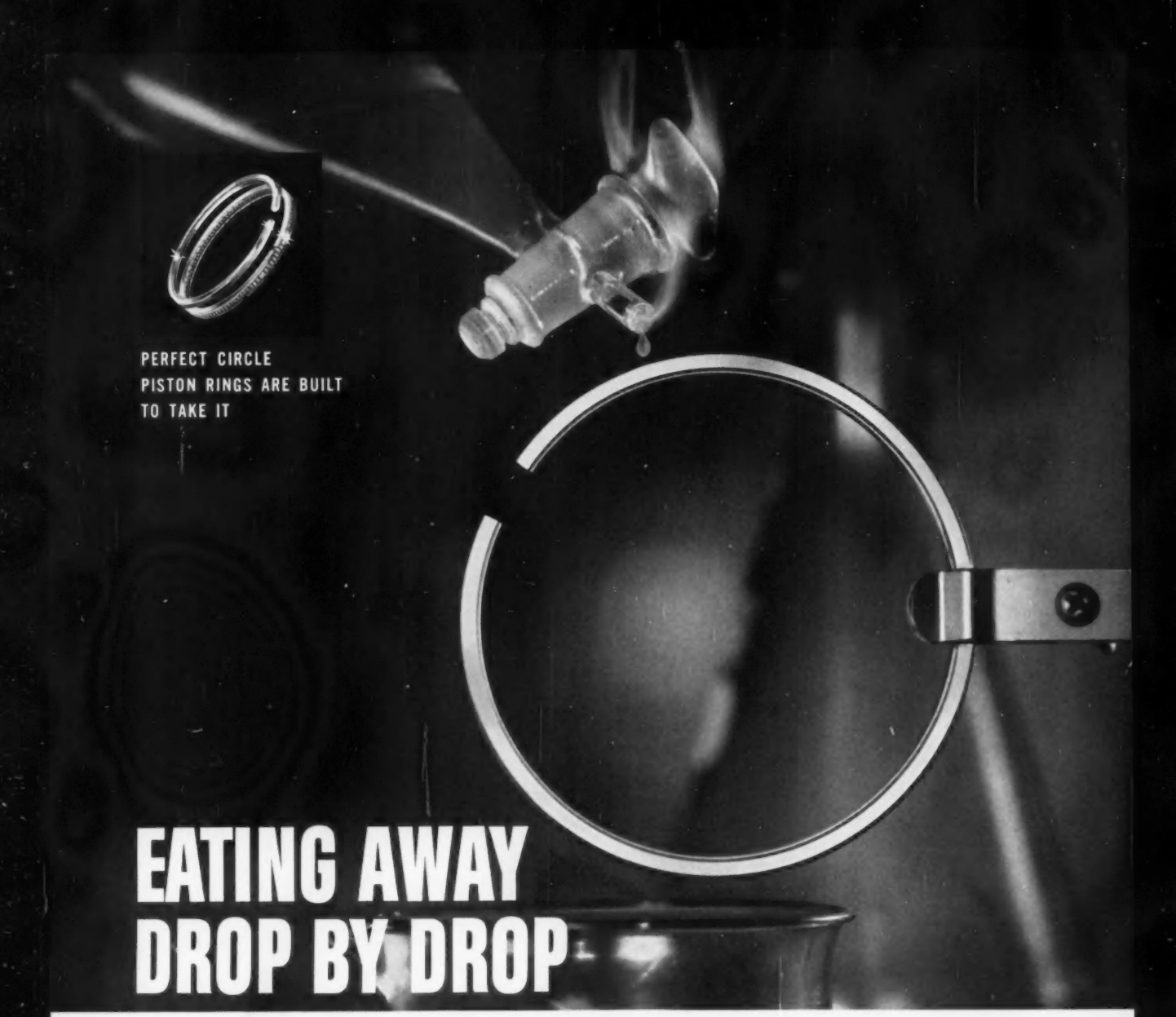

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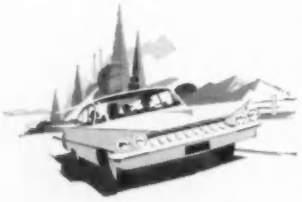

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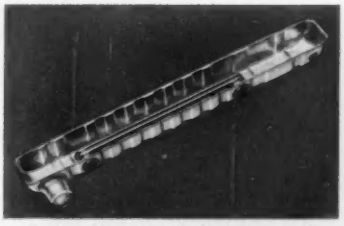

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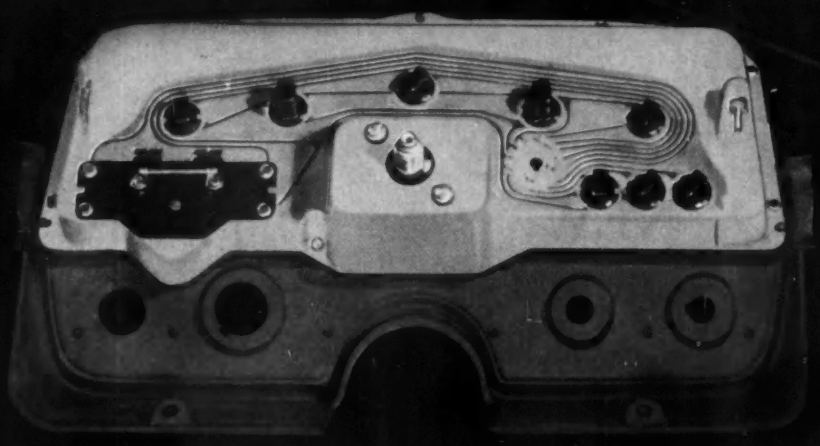

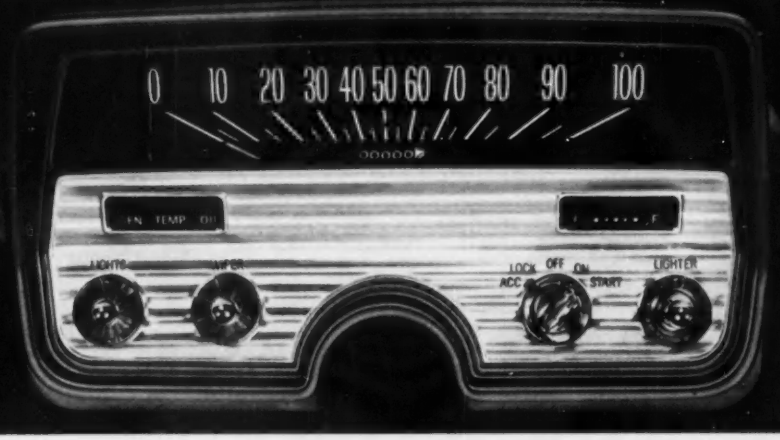

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Response of Small Electronic Components to intense Sound Fields and to Vibration, D. U. NOISEUX. Paper No. 236C. Investigation of effects of sound fields on components where largest dimension is 1 in.; vibration of component is excited by sound field and structure vibration; direct and feedback transmissions, i.e. sound field around structure depends not only on sound source, but also on radiation of structure vibration; latter depends also on loading effect of component vibrations of structure on which component is mounted; vibration and sound sensitivity.

New Concept in Automatic Landing and Navigation, F. K. PREIKSCHAT. Paper No. 237C. Requirements for future systems as stipulated by FAA and U. S. Air Force; navigational and landing system should use same airborne equipment so that aircraft will carry single package containing transponder and necessary data inputs and outputs; basic system is 3-way Interrogator-transponder which is explained in block diagram; technical details relating to pulsed FM Code Transmission, encoding and decoding, angular measurement, antenna system.

Development of In-flight Modulating Type Thrust Reverser for Single Engine Aircraft, W. T. KEHRER. Paper No. 238A. Feasibility study of its use for speed and flight path control during approach phase made with North American Fighter-bomber having J57-P-21A turbojet engine; design development through wind tunnel program selecting and adjusting exhaust gas patterns; flight test program showed that reverser selected produced adequate reverse thrust, up to 40% of not forward thrust, with small effects on aircraft stability, trim, and handling characteristics.

Sound Suppressor and Jet Reverser Effects on Aircraft Performance, W. R. WALLY, R. N. GARDNER. Paper No. 238C. Design considerations in development of thrust reverser sound suppressor package such as effectiveness of device in its designed function, effect on basic engine efficiency in take-off and cruise, weight penalties, reliability, ease of maintenance, overall effect in operating costs; special features of DC-8 thrust reverser such as its in-flight capabilities; details of in-flight uses; performance curves.

Low Cost Cargo Aircraft — Turboprop or Turbofan? I. G. CARTAINO, R. B. JOHNSTON. Paper No. 239B. Reexamination of State of art using Rolls Royce Tyne engine and Allison T-61 data while turbofan powerplant data are based upon Pratt-Whitney J-57 fans and General Electric aft fan versions of J-79; two cost methods selected are 1960 Air Transport Assn. direct operating cost and Rand costing method; it is found that selection cannot be made on basis of cost alone, but on engine availability, operating constraints encountered and preferences of people involved.

Survival Consideration for Interplanetary Missions, E. A. SMITH, R. W. CONNOR. Paper No. 244A. Problem is examined for round trip Mars mission; effects of performance and payload requirements on philosophies of escape and on-board survival are studied for particular vehicle having four different propulsion systems; resulting selection of on-board survival; subsystems are described from standpoint of three basic design techniques; duplicating of vital systems, multiple uses of vital systems, and repair capability.

Maintaining Confidence of Space Crew in Their Life Support System, R. B. WILSON. Paper No. 244B. Data on environmental parameters that must be controlled in satellite cabin carrying crews of 2 to 4 men on missions of 1 to 3 wk duration; display design that will indicate condition of these parameters is proposed, and suggestions made for instrumentation design; ways and means of verifying

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Engineering Evaluation of Algae, J. J. KONIKOFF. Paper No. 244C. Survey of data relating to design of photosynthetic gas exchanger capable of supplying oxygen requirement for man confined in space vehicle; growth of algae under controlled laboratory conditions and gas exchange equivalence of man-algae system; use of photosynthetic gas exchanger as source of oxygen; major problem areas are: algae selection and chamber geometry, energy source, gas exchange and separation techniques, and maintenance of equilibrium of system and waste management.

Human Factors Criteria in Manned Anti-Submarine Weapon Systems, D. B. MORRIS. Paper No. 244D. Discussion of human engineering aspects of ASW combat systems is limited to manned airborne systems, with emphasis upon projected future systems design; design criteria with regard to functional presentation of accurate tactical information to aircraft commander, copilot and aircrew, vision adequacy, air crew workstation and basic human engineering criteria; suggested general frontal configuration adaptable to helicopter or patrol and attack aircraft is offered.

Space Systems Training Devices, G. F. RABIDEAU, D. L. SCHLOREDT. Paper No. 245D. Review of associated training requirements and discussion of number of hypotheses concerning desirable characteristics of such training, and training devices; economy of operation and maintenance; use of personnel selection techniques to determine psychological fitness; tabulation showing complexity of space crew task components relative to extent of required training; general guidelines for design of such devices.

Experimental Studies of Combustion Chamber and Feed System Stability During Throttling of Regeneratively Cooled Liquid Hydrogen-Fluorine Rocket Engine. E. W. OTTO, R. A. FLAGE. Paper No. 246B. Results of experimental program carried out at Lewis Research Center in which combustion-chamber and feed-system stability and noise were observed while throttling engine over 6:1 thrust range; predominant frequency of combustion-chamber noise was 200 cps and remained essentially constant over range of combustion-chamber pressures.

Review of Able, Ablestar Upper-Stage Vehicles or Simplicity — Sure Road to Reliability at Low Cost, W. D. STINNETT, J. S. ROBBINS, D. HOLZMAN. Paper No. 246D. Able system is optimum second stage configuration for use with Vanguard booster; Ablestar liquid rocket system is its logical extension; differences between two systems which achieved 16 successful probes; sequence of operation; Able concept of field operations objective of which was to provide vehicle insuring minimum interference with existing booster facilities and operations, minimum launch time and maximum success at low cost.

Altitude Start Capability of Existing Large Liquid Propellant Rocket Engines, W. F. EZELL. Paper No. 246E. Application of existing Rocketdyne engines to second stage vehicle applications is examined with respect to potential engine start problems associated with low ambient pressure of high altitude; it is shown that existing booster engines as used in Saturn and late model Atlas missiles are directly applicable; with minor modification, earlier models as used in Thor and Jupiter missiles are adaptable to second stage applications.

Review of Aircraft Instrument Problems, G. T. GEBHARDT. Paper No. 247A. Transition from ground roll to climb-out is part of flight regime not effectively instrumented as desired on jet transports; instrument considered for indication of rotation angle is coefficient-of-lift transducer; flight test program to evaluate instrument; possible approach to altimeter problem is to use two servo-driven altimeters and one stand-by pneumatic altimeter in cockpit; air temperature probes used; accuracy problems; air data system requirements and recommendations.

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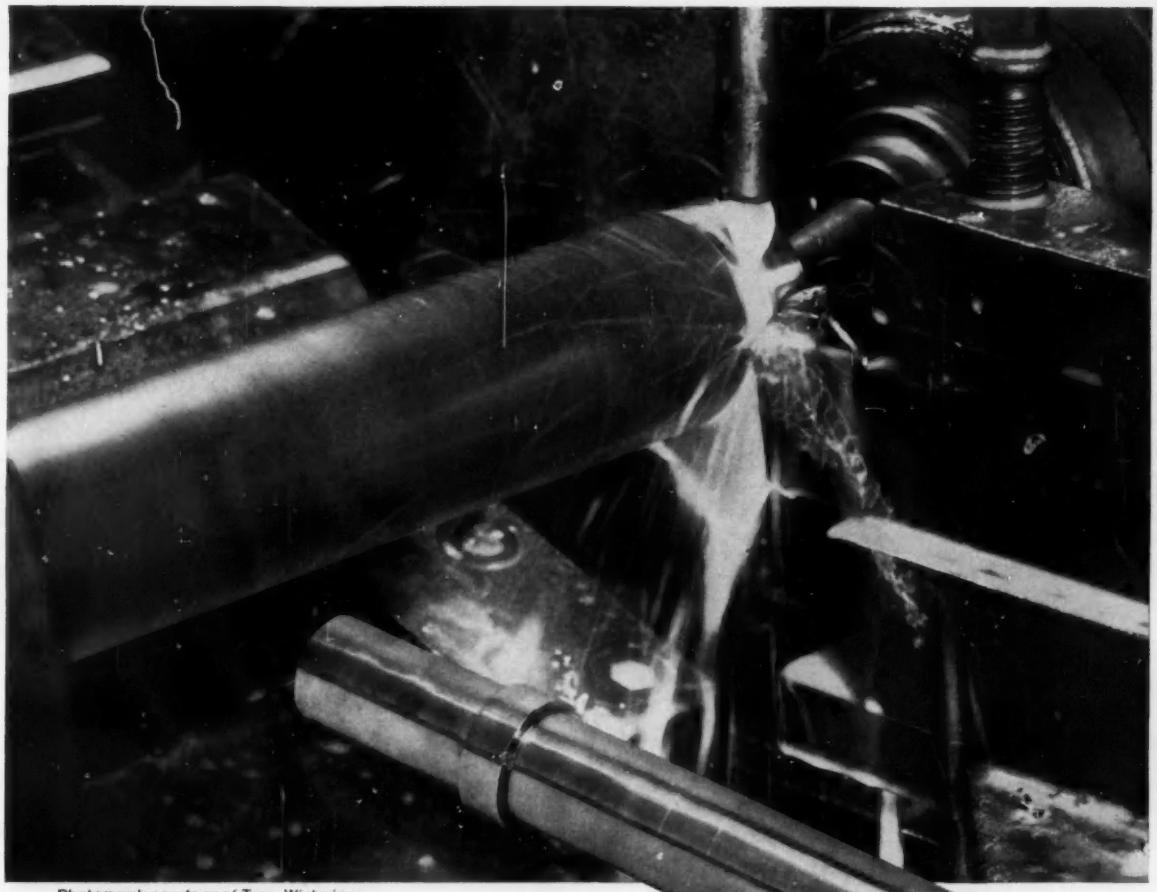

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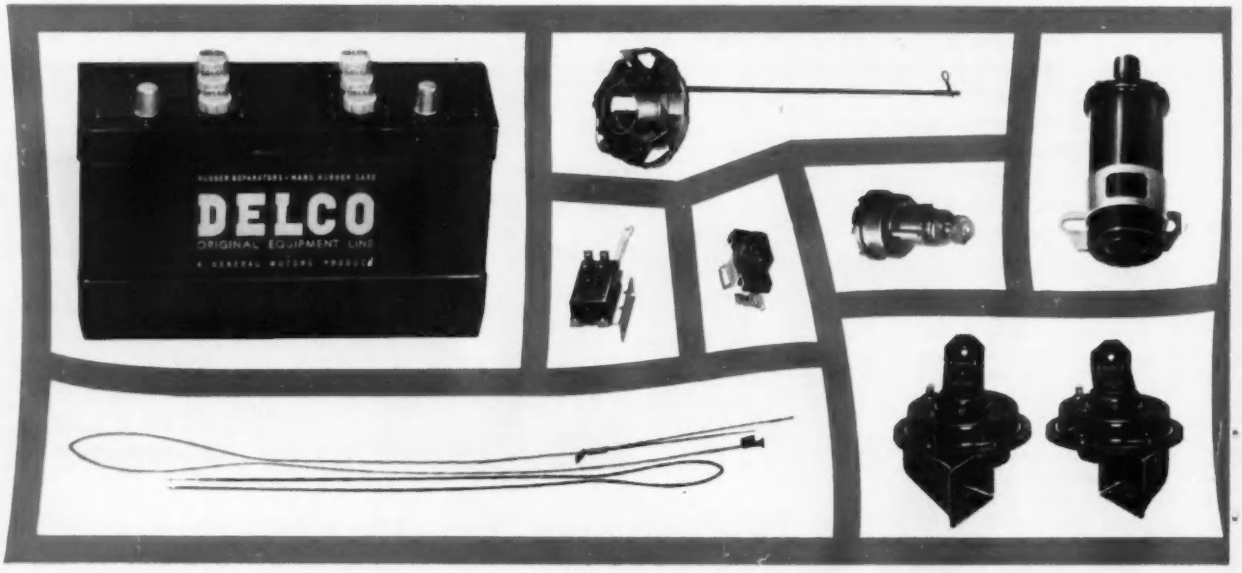

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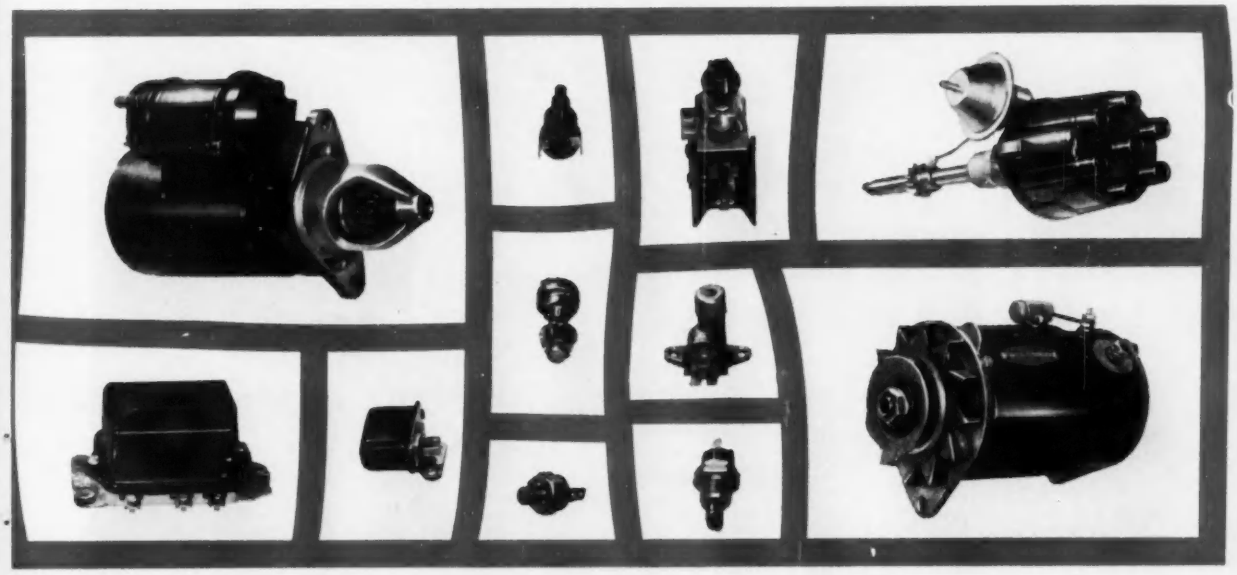

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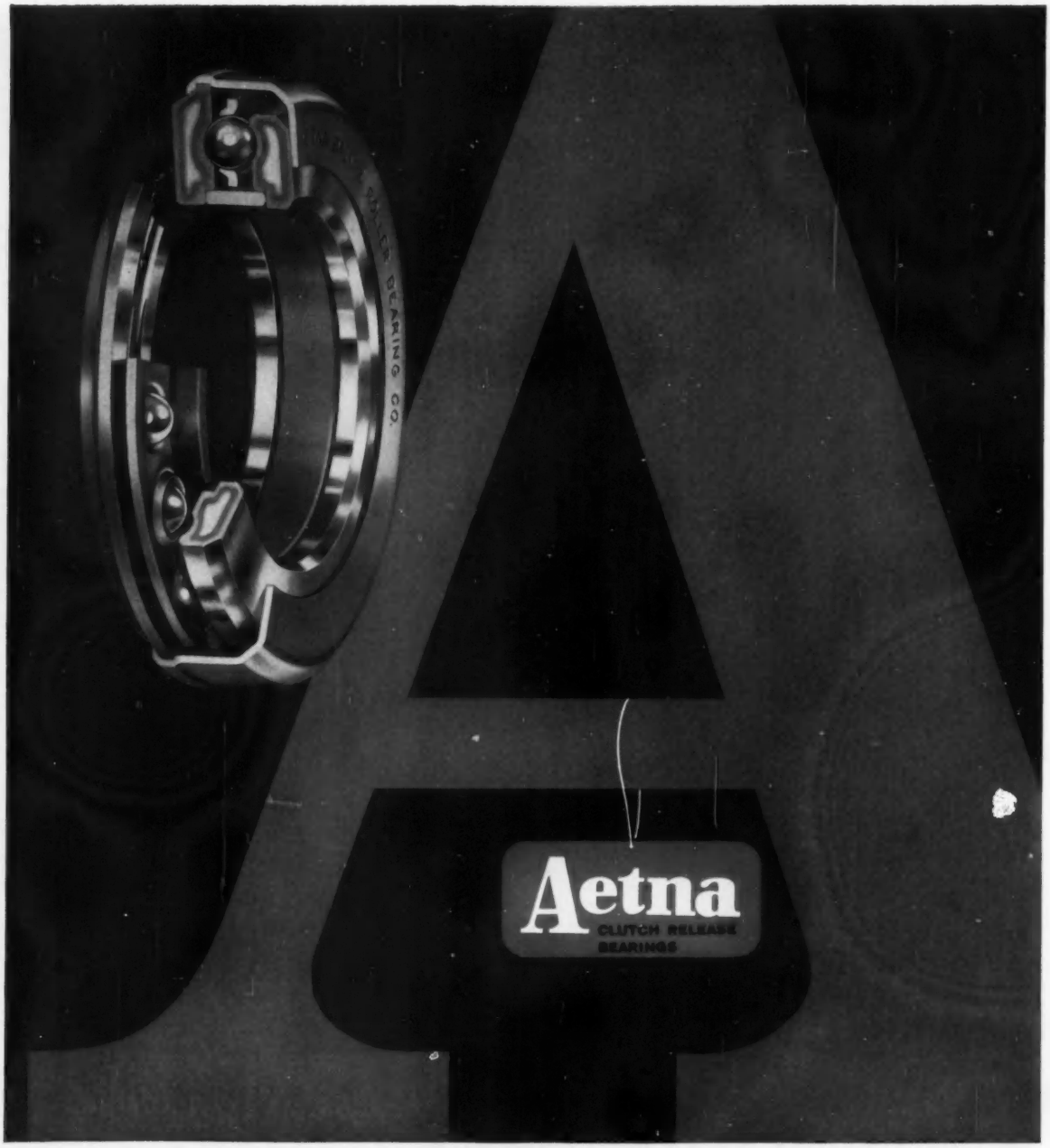

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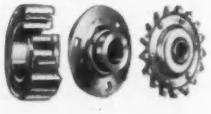

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Oil-soluble magnesium sulfonate

Typical Physical Properties

Base Number (mgs KOH/gr sample)	300
Magnesium Sulfonate, wt. %	30
Magnesium, wt. %	7.2
Water, wt. %	0.5
Mineral Oil, wt. %	47
Viscosity @ 210°F, CS	200
Flash Point, COC	360°F
Specific Gravity	1.07
Pounds per gallon	8.9

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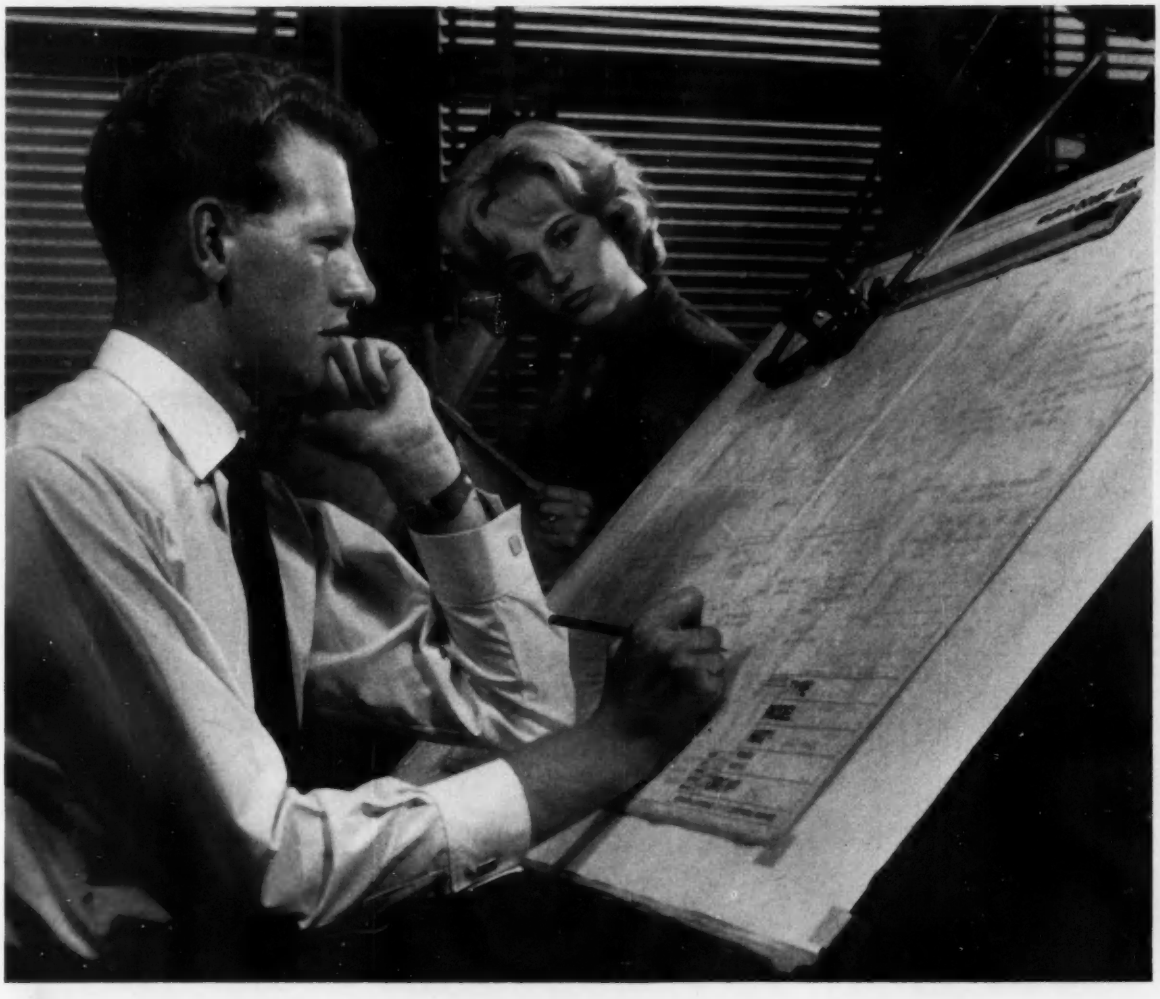

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What can you do with an idea-plastic like this? Automotive designers are putting it to work now in oil-pump gears, automatic transmission parts, oil-seal rings, suspension ball joints. Check into the places where a tough, high-impact plastic could do a better job than the material you're using, or could help you cut production costs. Then ask your molder for more details on Durez 16771—or write us for Bulletin D203, which describes the material and its capabilities.

DUREZ PLASTICS DIVISION

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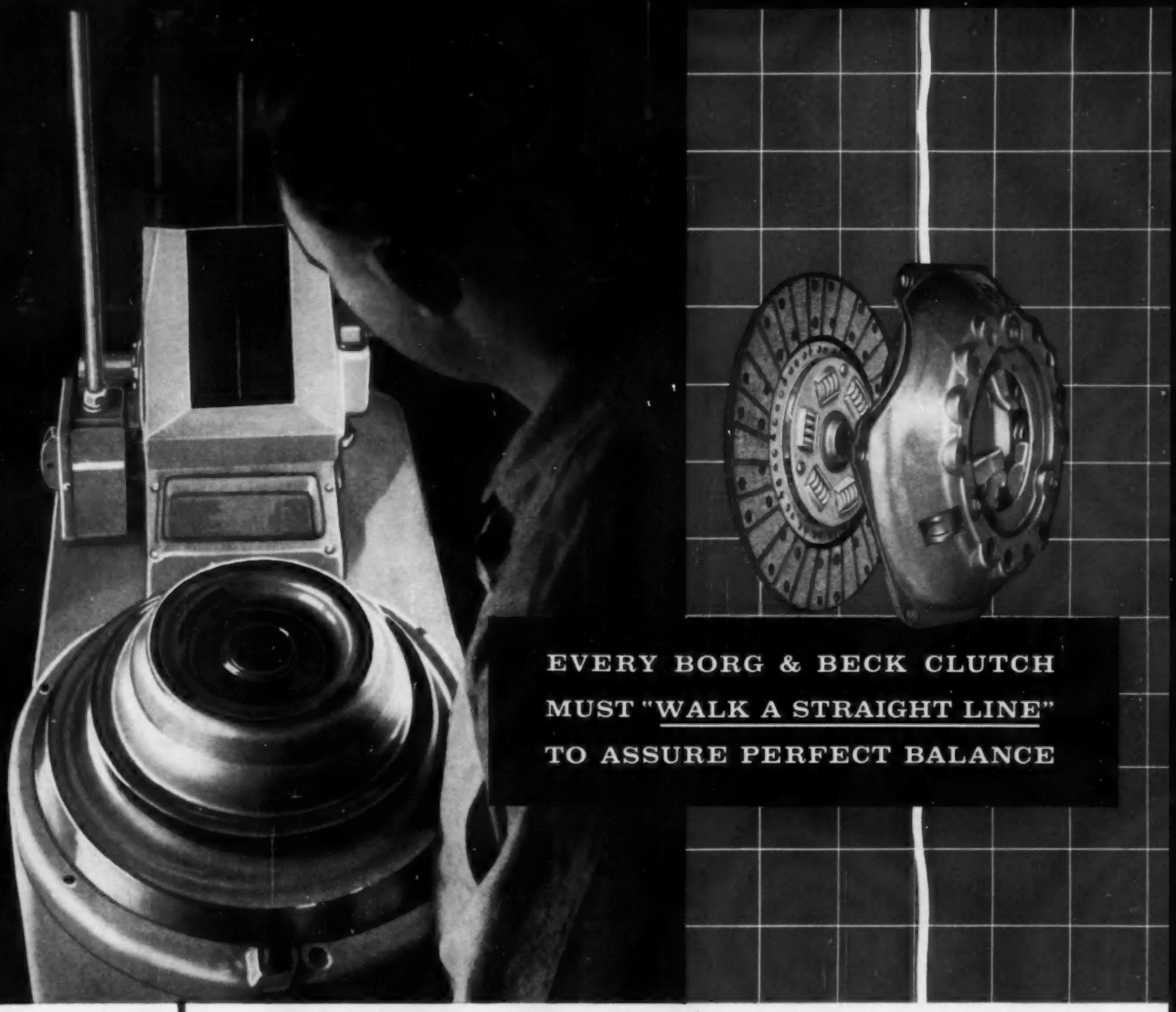

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MUST "WALK A STRAIGHT LINE"
TO ASSURE PERFECT BALANCE

Probably the most important single quality in a clutch is *balance*—because balance means smoothness of operation, not only of the clutch but of the engine as well.

That's why Borg & Beck clutches are checked for balance, at operational speeds, on specially designed test machines. Even the slightest unbalance is instantly detected and carefully corrected. Perfect balance is assured, as shown above, when the electric beam of the oscillograph is vertically straight on the calibrated screen. And every Borg & Beck clutch must "walk this straight line" before it passes inspection.

This is typical of the extra care that goes into every step in the making of Borg & Beck clutches. It is your assurance of top quality, top performance, top value.

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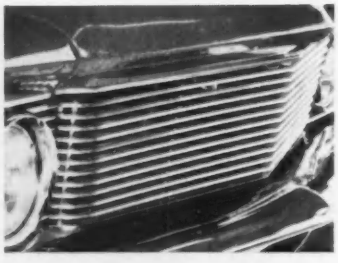

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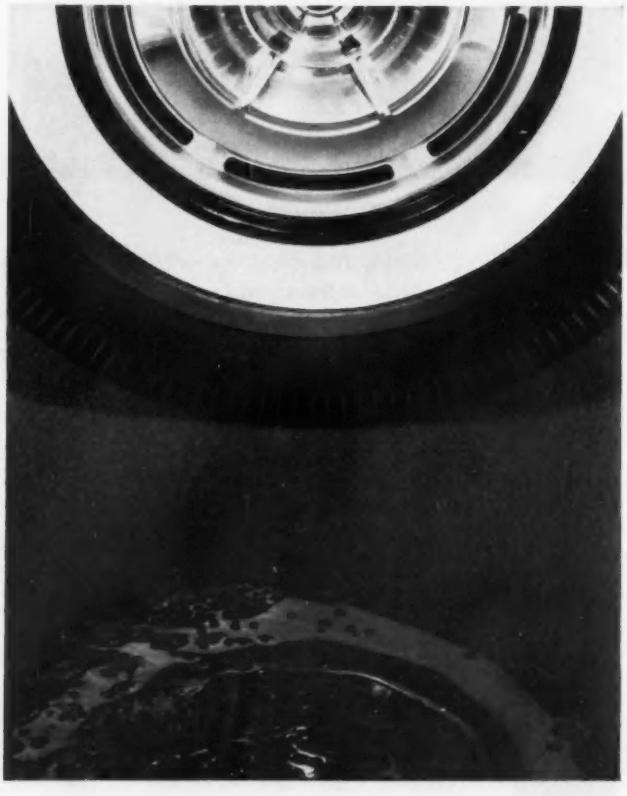

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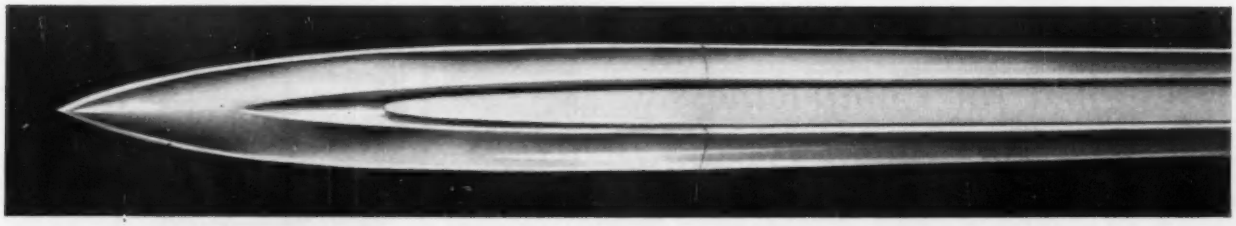

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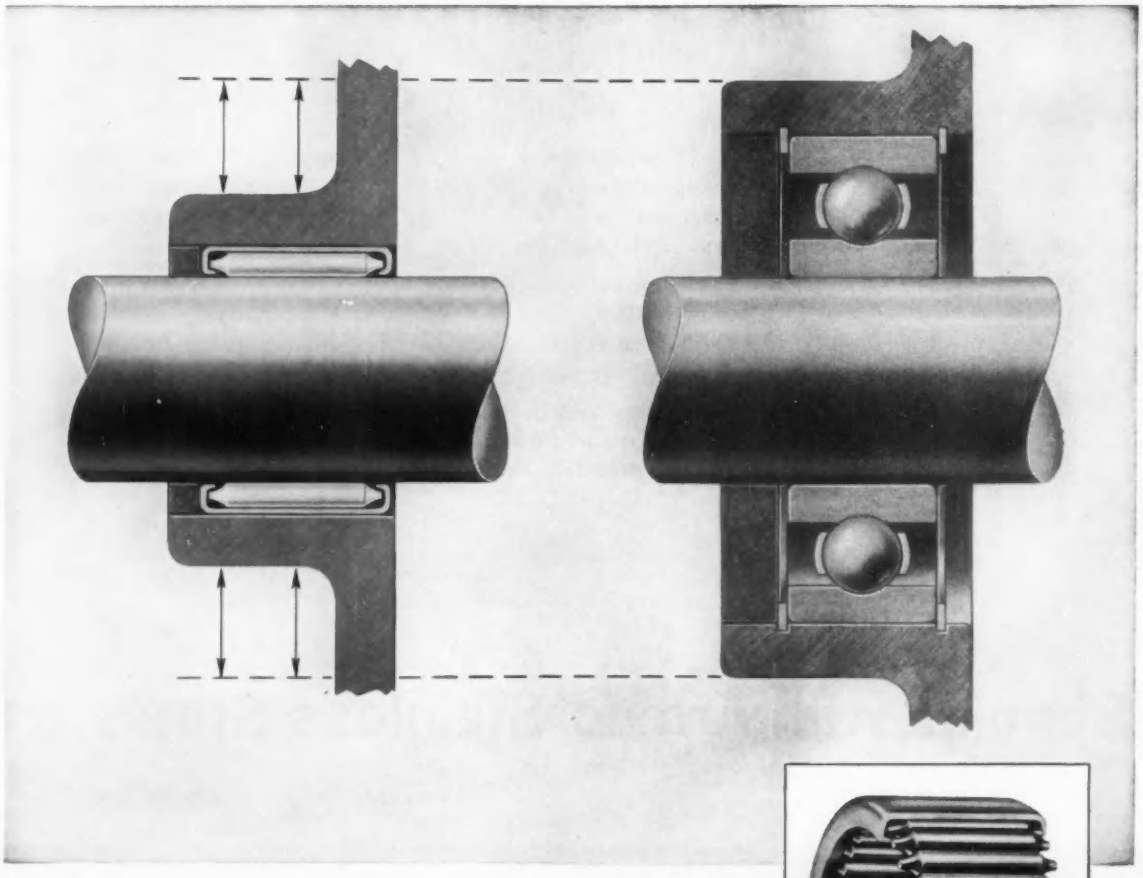

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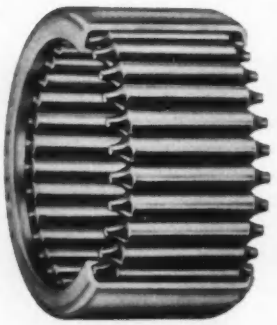
Simpler, more compact design is possible wherever Torrington Needle Bearings are put to work in eliminating friction problems.

These outstanding bearings offer a higher radial load capacity than any other bearing of comparable size. They are more compact, lighter in weight, and are lower in unit cost. The full complement of small-diameter precision rollers insures exceptional antifriction performance and long, maintenance-free service life. The turned-in lips on the outer shell guarantee positive roller retention. Installation and assembly are fast, simple, economical.

The unmatched design and production advantages of Torrington Needle Bearings have been proved in applications ranging from office machines to automobiles, washing machines to earth-moving machinery. Give *your* product the benefit of our antifriction know-how. Write or call Torrington—maker of every basic type of antifriction bearing.



TORRINGTON NEEDLE BEARINGS FEATURE:

- Full complement of retained rollers
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- Run directly on hardened shafts
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JOURNAL

For Sake of Argument

What's good about it! !

AN EXCLAMATION POINT — not a question mark — is appropriate to the tone normally used when we say:

"What's good about it!"

The phrase usually announces a mind made up; a conviction that nothing is right about the object or event concerned.

But make the words a sincere question, and you have the soundest of approaches to almost any problem. Asking "What's good about it?" has prevented the fast destruction of more than one eventually-useful proposal thrown to an impatient committee or conference. The question has kept alive many an idea which otherwise couldn't have survived the initial exclamation-point attack.

A top car engineer, one day back in the '20s', was explaining to an editor why supports were necessary for car windshield glass in positions which obstructed vision. Knowing no better, the editor asked: "Why don't you just curve the glass around each end?" . . . The answer, of course, was: "Well, nobody's found any way to *bend* glass!"

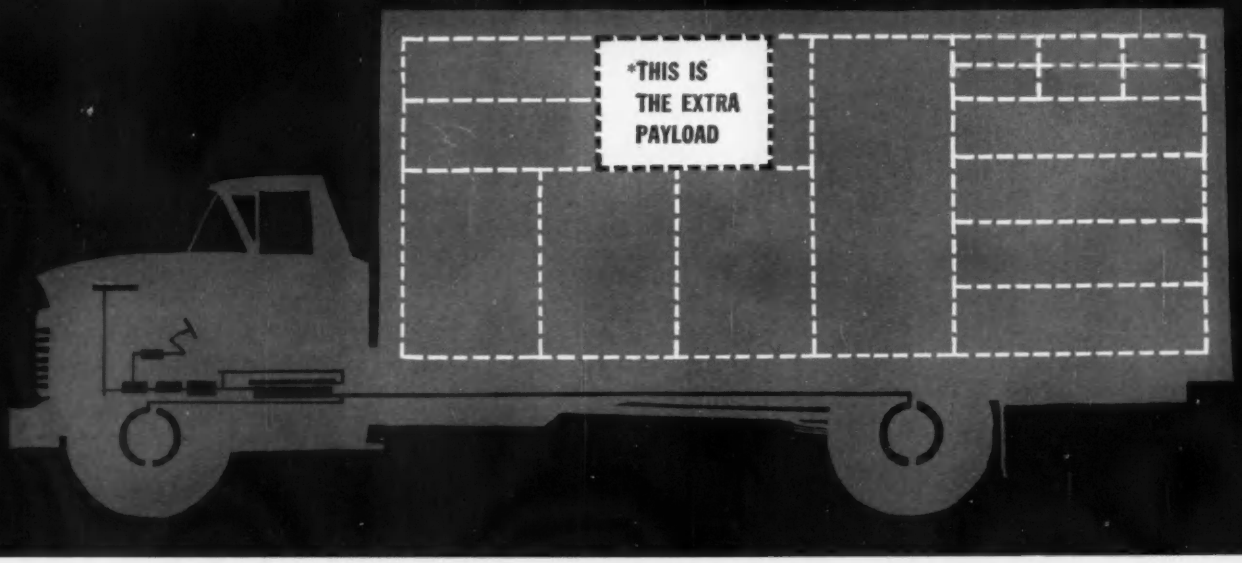
That same editor has more than once responded with superior air to editorial neophytes: "Well, there isn't any such thing as rubber type, you know!" . . . Yet, today a whole program to increase SAE facilities for printing full length papers rests largely on a new process which optically stretches or compresses lines of "cold" type.

Bent glass and rubber type and a million other potentials of the '60s are commonplace because some men and some groups kept asking "what's good" about every newly suggested concept. By the time they started to find out what was wrong, the urge to realize the good was strong enough to keep them trying until successful.

Norman G. Shidle

BENDIX HYDROVAC® POWER BRAKES

pyramid profits with extra payload*



PAYLOAD—Hydrovac Power Brakes weigh less, permit increased payloads up to several hundred pounds.

PRICE—Hydrovac Power Brakes cost *less to buy, less to operate, less to maintain.*

PROTECTION—*Built-in standby safety . . . manual braking available in case of power failure.*

More Bendix Hydrovac vacuum power brakes are in use than all other makes.

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

chips

from SAE meetings, members, and committees

ONLY 3 batteries in 10 were removed from service in 1960 because of factory defects, according to Delco-Remy data. In 1956, 4 of every 10 were because of factory defects. The 1956 figures showed also that 2 batteries in every 10 removed from service were discharged batteries. All other "removed" batteries were classified about equally among abusive treatment, broken case or covers, and worn out classifications.

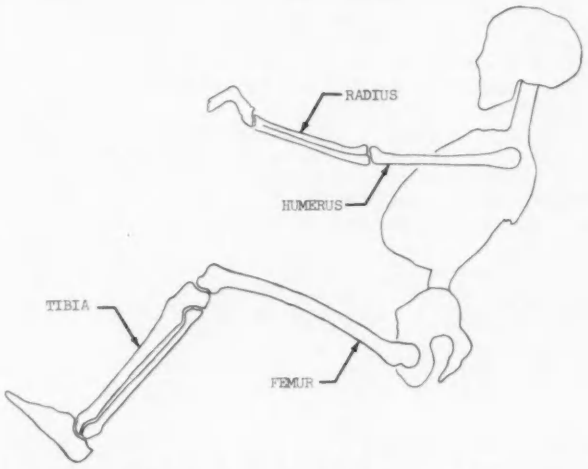
Need in field service for much improved battery testing is revealed by study of reasons for the discharged batteries by Delco-Remy. Bulking large in the list of reasons are such things as: (a) use of inaccurate test equipment; (b) failure to follow test instructions properly; and (c) borderline cases where field tests condemn discharged batteries which are later found by laboratory tests to be still good.

REGENERATIVE COOLING of liquid propellant rocket engine thrust chambers has been employed in most of the rocket designs since Goddard's initial experiments with a small liquid oxygen-alcohol engine. Initially, the use of one of the propellants to cool the engine was imposed by the lack of today's advanced materials, even for short duration operation. Even now, with better materials available, the use of new propellants and longer operating life for the rocket engines has maintained the need for regenerative cooling.

As a result of this design feature, firing times for these liquid propellant rockets have reached 15 minutes per run, with a total cyclic life of as much as 10 hours. In comparison, most solid propellant rockets (for which regenerative cooling is not applicable) have required a maximum firing time of 60 seconds.

LUNAR FLIGHT TIME is expected to be from two to three days, while a trip to Venus would last about 150 days — to Mars 260 days.

RUBBER TIRES USED IN THE PARIS UNDERGROUND — to give noiseless operation, with high acceleration and deceleration — have chalked up over 130,000 miles . . . are still good for lots more, according to a recent report. Moreover, only one flat has occurred with these metal core tires in five years — and that one was caused by a work tool left along the track.



"OSCAR" is what Ford advance seat development engineers call this faceless fellow who sits so comfortably on nothing. So far, he hasn't answered their call, but has told them a lot of things about how to make humans comfortable, just the same.

He was sired by anthropomorphic data from many sources combined with synthesis by Ford engineers into one comprehensive report. Nobody has been so cruel as to let him know that really, he's just "a seated male 2-dimensional side-view template, complete with flesh-line contours and effective bone-link pivots."

Pyramiding

Here's a specific example of how concept changed MY idea into

By C. W. Gardner
Manufacturing Development-Manufacturing Staff,
General Motors Technical Center

CONSCIOUS and systematic exposure of a technical idea to technically competent people brings to our Manufacturing Development group better results than the much publicized "brainstorming" techniques. Pyramiding of practical ideas can result when the comments and criticisms come from people whose experience makes them familiar with the problem involved.

A "pyramiding session," as we operate it, usually begins with disclosure of an idea by one member of the group. Then comes discussion — pro and con. Then, finally the combining of the know-how of all; the adding together of the best knowledge of all the group.

A good example of how pyramiding works occurred several years ago when we wanted to reduce the cost and improve the quality of generator armature commutators.

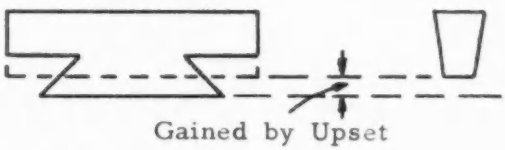
There were 23 copper bars in each commutator, and they were shaped like this:

They were blanked from bars of drawn or rolled stock, and there was a slug lost from each bar:

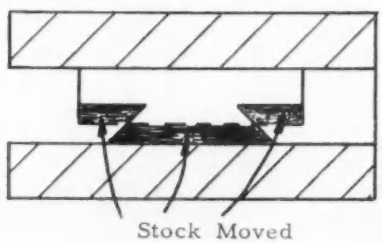
We had tried many ways to make this bar from a round wire, which was a material of much lower cost.

I had, very likely from the process of illumination — which is very different from inspiration — an idea which I thought was pretty good. I was so enthusiastic that I at once called several people to my office to describe the process. Naturally, I called only those who were capable technically of appreciating the idea. I wanted the approval of my peers. I was going to start with a round wire and draw it to a keystone shape — thus:

Actually, the height of the keystone would be less than the finished bar:



I planned to feed this wire into a cold heater and upset it to form the dovetails:



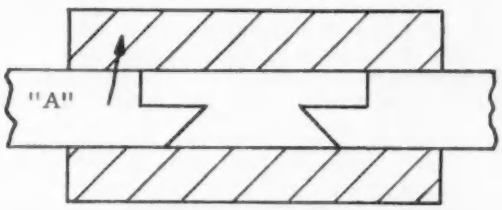
I would have a bar with no loss of material, and made from very low cost copper. I showed the sketches to my fellow experts and invited their comments, which I felt certain would be highly complimentary. The first comment was a question. How many was I going to make at one stroke of the press?

makes ideas better

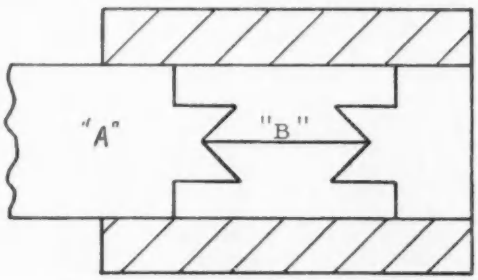
systematic exposure of a manufacturing

OUR idea . . . and into a success.

This was irritating, and I got a little sarcastic — remarking that I saw no reason to complicate the process by trying to double up. With patience and pleasure, he explained that it was doubtful if the process would work making one at a time. He gave this reason:



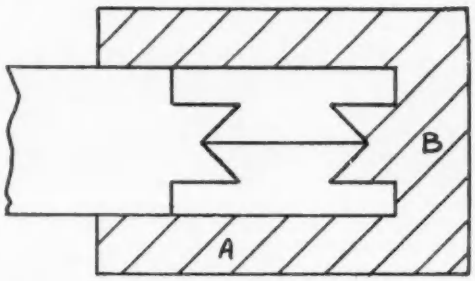
He said that the wedging force in the punch "A" would drive it so hard against the die wall that I would have trouble with galling:



If I made two at once, the punch would be balanced and would float without excess side wall pressure. Also, as a unique feature, the surfaces at "B" would mutually support each other and need no die wall.

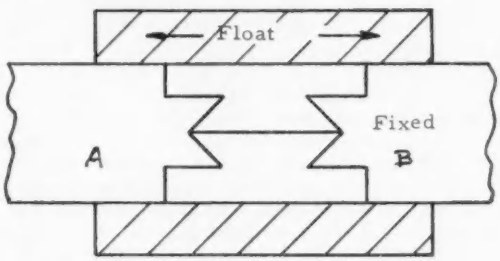
I had to accept this because the tooling was no more complicated and the production of the cold upsetter was doubled.

The next comment was another question. Was the die to be fixed, or would it float? In other words, would the punch at the bottom of the die have a fixed relation to the die? It certainly seemed as though that was the simpler construction and I saw no reason to complicate it. He suggested that it would be better to make the die more complicated if it would make it workable:



If "A" and "B" are fixed and the movable punch has the duty of forming its dovetails and also pushing the piece onto punch "B" to form dovetails in the other end, it would do a uniform job only if the movement of the pieces in the die was frictionless. Any pressure on the side walls would induce friction, which would subtract from the available pressure to upset the dovetails at "B."

If the die floated — had possible movement in the direction of punch movement, any friction effect would cause the die to move with the piece, permitting the full force on "A" to be applied on "B."



The pyramid was built and the process was a success. I no longer had an idea. WE had one.

To Order Paper No. 277A . . .
from which material for this article was drawn, see p. 6.

1961 European Passenger Cars

as seen at 1960 Fall Shows

By Aubrey Pershouse
General Motors Overseas Operations

IN October and November 1960, the Paris, London and Turin Shows took place in that order, this being an off-year for Frankfurt.

Latest available information indicates that attendance at the London and Paris Shows was lower than a year ago, while at Turin there was an increase of about 20%.

In contrast to the 1959 Fall show season, when many important new English models in particular were seen, there was a definite dearth of new models this year, while really new technical devices of any readily apparent great significance were lacking.

Trends at 1960 Shows

Previous European Show articles in the SAE Journal in recent years have identified trends which may be said to have continued, but at reduced tempo, in the case of the 1960 Shows.

Automatic transmissions are becoming more common on European cars, although no basically new designs were to be seen this year. Employment of Italian body-builders to assist in styling high-volume production cars continues, and increasing numbers of cars with disc-brakes, particularly from the British source, are again to be noted. The trend to upgrade mini-cars was not so much in evidence this year, but indications are that the basic smaller mini-car models are losing sales appeal fairly rapidly.

There is limited evidence to show that the Italian special body-builders are returning to more rounded lines in the case of the expensive 2-passenger sports coupes in which they specialize.

Installation of new engines in otherwise relatively unchanged vehicles was somewhat of a feature at the 1960 Shows, examples being Simca, Volkswagen, Fiat 600, its German counterpart the Jagst, the new 6-cyl Standard Vanguard power unit, and Vauxhall's new larger 6-cyl engine. The last is completely re-designed and has excellent torque characteristics throughout its speed range. Another new engine is the Peugeot 404, but in this case it is complemented by a new body and other mechanical components. In general, a trend seems to have been established toward more robust and higher revving engines in mass-produced medium-sized European cars centered around the 1.5-liter group.

Importance of Individual 1960 Shows

PARIS — The following new models of importance were introduced either earlier during 1960 or for the first time at the 1960 Paris Show: 1961 Opel Rekord, Peugeot 403 Sept, Peugeot 404, and 1961 Ford Taunus 17M.

The Opel, in 2-door, 4-door, and station wagon models, has an entirely new body with some mechanical improvements, including improved suspension. Front springs are softer, rear springs are now of the split leaf type with progressive action, and shock absorbers are modified to match the new spring characteristics. The new Opel Rekord body has a lower silhouette and thinner roof-line coupled with appreciably greater glass area than the model which it supersedes. Despite the lower roof, the car has greater rear headroom than before, while the interior generally is wider and more comfortable. Wheelbase is unchanged, but the strongly accented horizontal styling gives an impression of considerably greater length. There are numerous additional detail refinements.

The Peugeot 403 Sept is in fact the existing 403 body with somewhat simpler trim and with the same basic engine as the 403 model. This new car replaces, to some extent, the rather old-fashioned Peugeot 203 which has been a stand-by of this make for many years. Peugeot's other new car, the 404, sports a new body, designed in consultation with Pinin-

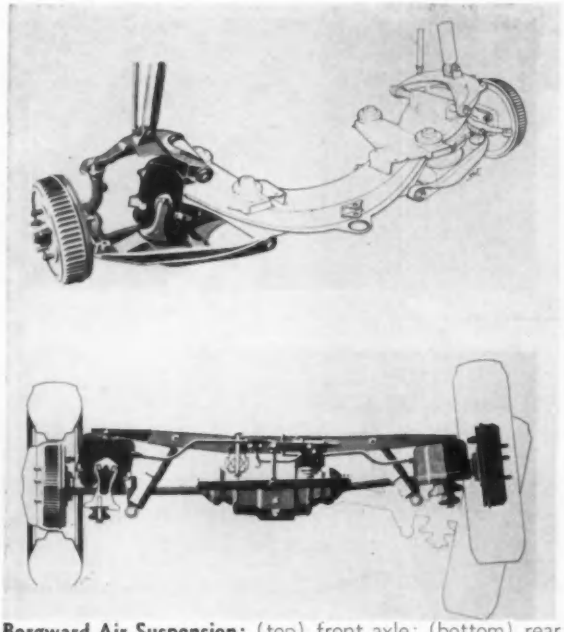
1961 Ford Taunus 17M Sedan.

1961 Opel Rekord Sedan.

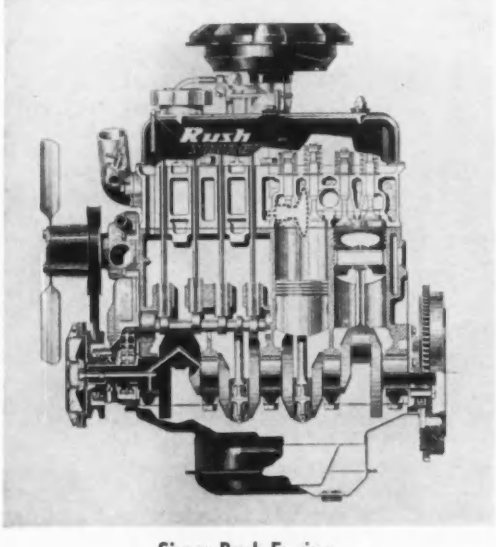
New Pinin-Farina Coupe Body on 4.1-liter Ferrari.

Farina. The body lines are strongly reminiscent of this firm's work for the English BMC bodies which appeared during 1959. In addition, the 404 has an entirely new, inclined, 4-cyl OHV engine and other mechanical features of some interest, including Macpherson type independent front suspension and Peugeot's well-tried worm-drive rear axle.

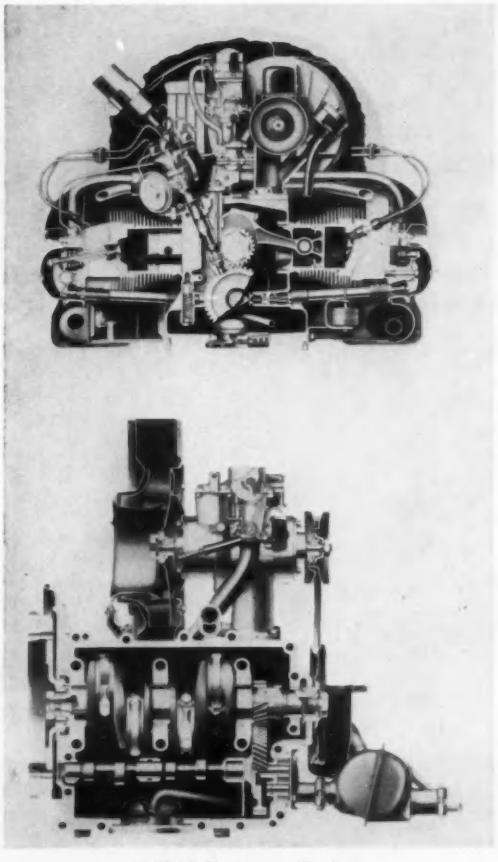
The 1961 Ford Taunus appeared for the last few days of the Paris Show only, and attracted considerable attention. With the exception of the front end grill and headlamp styling, which is somewhat controversial, the car has a modern and pleasing appearance. It uses slightly curved windows, and the side and rear views are distinctly good. The car interiors also came in for favorable comment. It is claimed that some 200 lb weight has been saved in comparison with the previous model. This Taunus will be made in 2-door, 4-door, and station wagon form and will still be called the 17M, although the German Ford 1.5 liter, 1498 cc (91.4 cu in.) engine will be standard and the 1.7 liter, 1698 cc (103.6 cu in.) unit (previously standard in this car) will be an



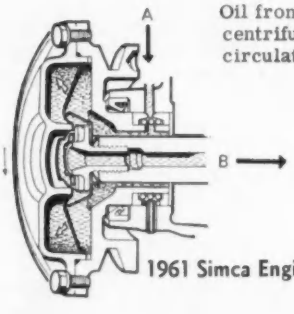
Borgward Air Suspension: (top) front axle; (bottom) rear axle.



Simca Rush Engine.



1961 Volkswagen Engine.



Oil from engine enters at A; centrifuged oil returns to circulation via B.

1961 Simca Engine Fiat-type Oil Filter

optional extra. The rear axle ratio on the heavier, superseded model, was 3.90/1 and this has been brought nearer to unity at 3.56/1 on the new, lighter car.

Another feature of this Paris Show was the announcement by Vauxhall of a new, larger 2651 cc (162 cu in.) engine coupled with the option of a Hydra-Matic transmission for its 6-cyl Velox and Cresta models. This transmission has been specially tailored to the new Vauxhall engine performance which features excellent torque characteristics throughout the speed range. A closely related Hydra-Matic transmission was put into production for the Opel 6-cyl Kapitan shortly after the Show season finished. It is interesting to record that Borgward is now offering the British Hobb's transmission, under the name of Hansamatic, as an option on both its 4 and 6-cyl cars. This transmission was described in the European Show article in the SAE Journal of February 1959.

Simca introduced four versions of a new 5-bearing 4-cyl engine for their Aronde and Ariane series cars. This is described in more detail later in this article.

In France considerable publicity was devoted to the new Renault Ondine model, which is merely the highly successful Dauphine plus a 4-speed transmission and some other refinements. Citroen announced a new convertible for the ID19 and DS19 cars which is to be made by the body-building firm of Chapron. Apart from this offering, French custom body-builders were not importantly represented. Pinin-Farina exhibited a hard-top 2-door coupe based on Corvair components with reduced wheelbase.

A feature of this year's Paris Show was the great interest shown by the crowds in the exhibit of the new American smaller cars. Styling of the new General Motors smaller cars was particularly singled out for praise in the French technical press. The interest in these cars was largely academic, as list prices after French duty and taxes put them well beyond the reach of the mass buying public.

The NSU-Wankel engine, which has been widely publicized in the technical press for some 18 months, was displayed at Paris in the form of a plastic, sectioned moving model.

LONDON — No new models of potential high volume made their first appearance at this year's London Show, although minor improvements and interior and exterior trim changes were much in evidence.

The new U. S. smaller cars were also shown here but did not arouse the same degree of journalistic adulation or public interest as had been the case in Paris. BMC showed a new station wagon for the small front-drive Austin 7 and Morris Mini-Minor cars, as well as a larger wagon for the Morris Oxford series, 1489 cc (90.89 cu in.), and the closely parallel Austin A55 line. Humber Super Snipe, with a face-lifted front end, became the first English car to provide a dual headlight arrangement.

Standard introduced a new 6-cyl engine for use in their biggest, Vanguard, series of cars. Lea-Francis, once an honored name in the sports car world, came to life again with a sports model which relies upon a hotted-up Ford Zephyr engine. The styling of this car came in for a good deal of adverse comment. Armstrong-Siddeley, a small-volume car of long standing, did not appear at the 1960 Show, having been discontinued by its makers in favor of their other products.

One particular technical item at Earl's Court merits comment, and that is the comparatively low cost gasoline injection device sponsored by the firm of Simms Motor Units. This device received a great deal of publicity when it was first announced. Some further details of the scheme are given below.

As far as the English industry's interest in disc-brakes is concerned, a very significant move is the offering by Ford of Girling disc front brakes as an option on its English 4-cyl Consul, and 6-cyl Zephyr and Zodiac models.

TURIN — In a year when notably few new models of importance made their appearance at the major European Shows, Turin provided some points of interest in addition to the usual display of high-class body-building and futuristic models. Lancia introduced a new front-drive 1500 cc (91 cu in.) flat 4-cylinder engine model, the Flavia, which incorporates many interesting design points. Wheelbase is 104.3 in., but because the engine is located forward of the front wheels there is an unusual amount of room in the 4-door integral type, modern and attractive sedan body. The engine, described later in more detail, and transmission with final drive, are all mounted on a readily removable sub-frame which facilitates assembly and subsequent service work. All four synchronized gears are indirect, and final drive goes through Rzeppa universal joints. Disc-brakes, stated to be a combination of Lancia's own patents with Dunlop calipers, are used all round. Front suspension consists of a transverse leaf spring with pairs of control arms while, unusually for Lancia, rear springs are semi-elliptic leaf type. The new Lancia follows the established policy of this company, which is to produce cars of technical excellence somewhat regardless of cost . . . and for this reason it cannot be classed as a very serious entrant into the high production group of European models. Price in Italy is given as $2770.

The Fiat 600 now has a larger 767 cc (46.8 cu in.) engine which replaces the old 633 cc (38.6 cu in.) power unit. Early in 1960, Fiat introduced a station wagon model of its smallest, 500 rear-engined series car. In this wagon, known as the Giardiniera, space is gained by putting the 2-cyl air-cooled engine in a horizontal position under the luggage deck. Both this engine, and that in the 500D series de luxe model sedan, have been enlarged some 20 cc for 1961 by a slight change in bore size. The standard model 500 sedan uses the unchanged smaller engine.

The Ferrari Super Fast car with body by Pinin-Farina gives some evidence of the interest in a more rounded line by the top Italian body makers. Many of the Italian body makers are now building special bodies on mechanical components of non-Italian derivation. Examples: the Italia, a Triumph TR3 with body styled by Michelotti and constructed by Vignale; the Innocente 950, an Austin-Healey

1961 European Passenger Cars

. . . continued

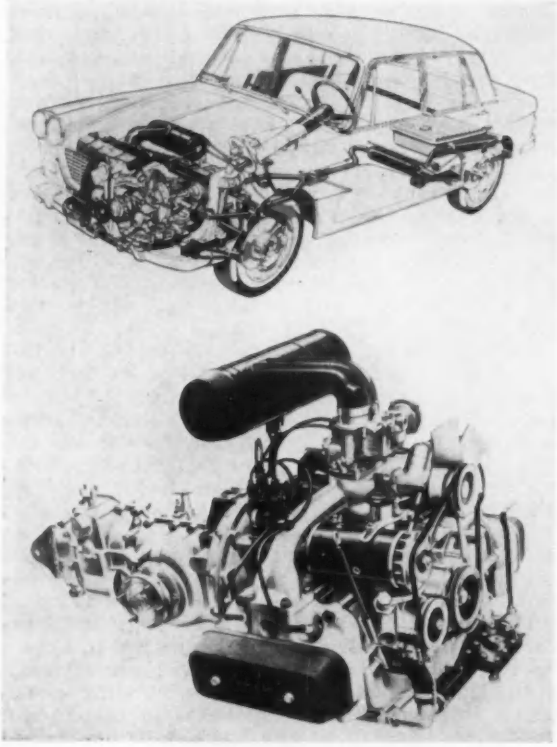
Sprite assembled in Italy with special body by Ghia; the Japanese Prince, also with Michelotti-designed body but built by Allemano; and Studebaker 6 and 8-cyl cars with bodies by Frua and Lombardi respectively.

Following are further brief descriptions of some of the new engines which appear in that important group of European cars having engine displacements of from 1150 cc (70.2 cu in.) to 1650 cc (100.7 cu in.).

Volkswagen Engine

The engine which has now been used for some time in Volkswagen station wagons and associated vehicles, is now used in the passenger car. It incorporates increased cylinder spacing, permitting the use of larger cooling fins. The crankcase is larger and has heavier main bearing supports, while crankshaft webbs are beefed-up to give rigidity for additional power. The head now has inclined valves instead of vertical, and these are seated in a wedge shaped combustion chamber. The camshaft is larger, and tappets and valves are modified for lower stresses and increased silence of operation. The carburetor has been revised, and ignition timing is now entirely controlled by vacuum without any centrifugal mechanism.

The results of these important changes are claimed to be as follows: an increase in bhp from 36 at 3700 to 40 at 3900 and an improved torque curve, coupled with greater silence and ability to maintain appreciably higher rpm for long periods with absolute reliability. In conjunction with a greater final drive reduction there is now improved flexibility in top gear. It is claimed that the revised ignition timing gives better fuel economy at the lower engine speeds.



1961 Lancia Flavia: (top) cutaway view of car; (bottom) engine.

Simca Rush Engine

The new Simca Rush engine appears in three closely related forms, and dimensions are similar to the replaced engines. The economy 6CV model installed in the Aronde Etoile 6 has a displacement of 1090 cc (66.5 cu in.), 7.4/1 compression ratio and develops 42 bhp at 4900 rpm; bore is 68 mm (2.68 in.) and stroke 75 mm (2.95 in.). The standard 7CV engine displaces 1290 cc (78.7 cu in.), has a 7.5/1 compression ratio, and puts out 52 bhp at 4900 rpm; bore is 74 mm (2.91 in.) and stroke identical with the 6CV above. This engine is used in the Etoile 7 and Elysee cars.

The Rush Super engine, of the same displacement as the 7CV, powers the more luxurious Aronde Montlhery and Monaco sedan models, the Ranch station wagon, and the Plein Ciel and Oceane coupes. It is also used in the Ariane car which has a body previously used for the larger Vedette 8-cyl cars. The latter series now has a more modern rear-end appearance. The Super engine has a compression ratio of 8.5/1 and puts out 62 bhp at 5200. A special edition of the engine, the Service model, is installed in the Chatelaine station wagon and develops 48 hp.

The basic changes in the Simca 4-cyl engine comprise a new cylinder block, crankcase and crankshaft. The 5-bearing crankshaft is a unique feature in a European mass-produced engine of this size. The additional bearings, in terms of the old engine, are interposed between numbers 1 and 2, and 2 and 3 main bearings in space previously occupied by crankshaft webbs. Other engine features include a new oil bath air cleaner which is claimed to give greater silence, a vacuum override control for the ignition advance, and a centrifugal oil filter located at the forward end of the crankshaft.

This device is made under license from Fiat and is also fitted to their 1800 and 2100 model 6-cyl cars. An impeller unit is keyed to the crankshaft and an aluminum bowl is bolted and sealed to the impeller. The fan belt pulley runs around the exterior of the impeller, and there is a degree of finning on the outside surface of the bowl to assist in oil cooling. By drilling the crankshaft, use of any exterior piping is avoided. The device filters the contents of the crankcase about every 10 sec and foreign bodies are thrown to the periphery of the aluminum bowl. The filter is claimed to be 2 to 3 times as efficient as the conventional automobile oil filter. It has the advantage that the engine oil should not, theoretically, have to pass through matter already filtered out. It is stated that even at idling speeds action is very efficient.

Smoother and more reliable operation, longer life,

greater silence, and improved economy are the results claimed for the changes made to the Simca 4-cylinder engine.

Peugeot 404 Engine

The new Peugeot 404 engine of 1618cc (98.7 cu in.) has several features of interest. It is installed in the car, which uses many of the well-tried Peugeot mechanical components, at an angle of 45 deg.

In the main it may be said to have been based on the 403 engine, but is larger, develops 72 bhp at 5400, and has good torque characteristics throughout its speed range. Bore is 84 mm (3.31 in.) and stroke 73 mm (2.87 in.) while compression ratio is only 7.2/1, presumably with the intent that regular grade fuels will be adequate in export markets where high-octane fuels may not be readily available. The engine has a spherical type aluminum head with inclined o.h. valves, while main and big-end connecting road bearings are more substantial than in the 403 engine.

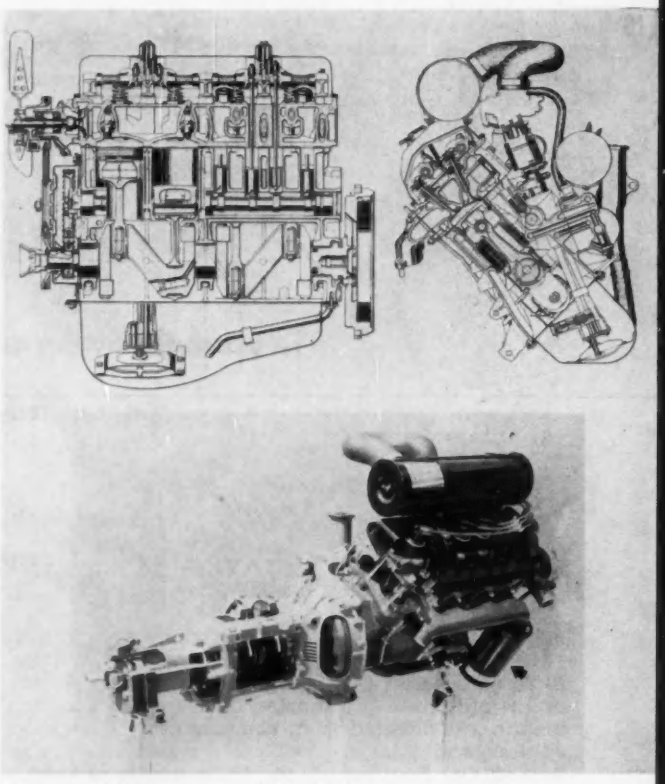
For some years, the 403 engine has been fitted with an electromagnetic automatically disengaging engine cooling fan. This feature is transferred to the 404 engine. It is claimed that, in addition to greater silence, it provides a fuel economy gain of from 5–10%, depending upon operating conditions. Fitting of a resonator chamber at the forward end of the exhaust manifold is an unusual feature. Peugeot states that exhaust pulsations in this chamber eliminate what would otherwise be a dip in the torque curve at a particular engine speed. The arrangement of the inlet system is also unusual in that each intake valve has a separate port which joins a square, sectioned gallery in the cylinder head. From the center of this gallery a single passage connects with the downdraft carburetor. The individual intake ports are plugged on the outside of the intake gallery. It would seem that by removal of plugs as required, multiple carburetor systems could very rapidly be installed on the Peugeot 404 engine.

Lancia Flavia Engine

There are several interesting points in the design of this water-cooled flat-four 1.5 liter (91 cu in.) engine which has a bore of 82 mm (3.228 in.), stroke of 71 mm (2.795 in.) and a compression ratio of 8.3/1. The engine has a 12-volt ignition system, develops 78 bhp at 5200 and runs easily at 6000 rpm. Crankcase, cylinder block, and transmission-housing are aluminum die-castings and all are split on the center-line; the engine sump is provided with cooling fins. Rather originally, the fan is located behind the pulley for the sake of reducing engine length. Again, somewhat unusually, there are two camshafts, driven by chain with hydraulic tensioning device. This feature, of course, permits use of light pushrods. Crankshaft bearings appear to be very generous in dimension, the engine has wet cylinder liners held in compression, and valves are set at an included angle of 39 deg over a hemispherical combustion chamber.

Low Cost Gasoline Injection

The previously mentioned Simms Motor Units' simplified fuel injection device merits some further description, as it received very wide publicity at the time of the London Show, particularly in the popular press, and English vehicle makers will no doubt follow its progress very closely. When fitted to a car in the 1.5 liter range, it is stated that the device weighs more than a single carburetor but less than any multiple carburetor arrangement. Cost has been estimated to be in the area of £10 ($28) before installation.



Peugeot 404 Engine: (top) longitudinal and transaxle sections; (bottom) engine as inclined in chassis.

The most distinctive feature of this system is that it employs a single injector, located approximately in the position normally occupied by the carburetor. At first sight, it is by no means clear how such an injector location can offer any advantages in distribution characteristics over a carburetor. The makers claim that fitting of their device results in improved volumetric efficiency due to elimination of any constriction of the gas flow by a venturi and, as a result, better performance and economy are obtained.

The system includes a single injection nozzle, a pump, and a sensitive, light weight, metering control. It employs a very short injection period, only 10 deg of crankshaft rotation. This period, it is said, can be timed to promote complete scavenging of the intake manifold for each cycle; thus no cylinder can rob another. The pump itself functions by mechanical deformation of the inner wall of a synthetic rubber ring which forces fuel through the injector nozzle.

Saturn engine

To match the Soviet capability of placing heavy payloads in space, called the Juno V, and redesignated the SATURN,

Based on paper by

Roy Healy

Rocketdyne, a division of North American Aviation, Inc.

THE H-1 rocket engine for the Saturn project (Fig. 1) is designed to produce a thrust of 188,000 lb to achieve an 8-engine cluster combined thrust of 1.5 million lb. To shorten development time the engine was adapted from components of the Thor, Jupiter, and Atlas engines. As a result, the engine was off the drawing boards, built, and successfully fired less than four months after inception of the program.

While the new engine employs the thrust chamber, turbopump assembly, gas generator system, and control valves developed in the missiles from which it was derived, many design changes were incorporated. Components were also strengthened and refined to accommodate the increased thrust level specified for the H-1, the previous engines being rated at 150,000 lb. Repackaging has improved compactness and accessibility in the booster boattail, resulting in a lighter assembly with reduced envelope dimensions.

The H-1 engine is contrasted schematically with a late model Jupiter IRBM engine in Figs. 2 and 3. It may be seen that a simple cartridge starter, bolted to the engine, replaces the two ground start tanks, with their complex fill, vent, and level sensing devices, pressurizing system, and quick disconnects. Lubrication and cooling of the turbopump gears and bearings are accomplished by using engine fuel with a small amount of additive, instead of the formerly used 20-gal lubrication oil tank, with its pressurizing regulator, valves, filters, and vent provisions.

Marked simplification of the engine has resulted from the relaxed thrust control requirements of individual engines in the clustered booster, compared to the requirements of a single-stage ballistic missile. Calibrated orifices replace the complex thrust level control system used in the Jupiter.

The major improvement was a radical simplification of the engine starting and shutdown sequences, resulting in the elimination of numerous subcontrols and electrical sensing devices. The starting sequence is controlled by fuel discharge pressure instead of the event-sensing, electro-mechanical devices previously used. The electrical system for engine control has consequently been reduced to approimately 5% of that used on previous engines. Engine pneumatic requirements have been similarly reduced.

The main engine components are the thrust chamber, turbopump assembly, gas generator, pyrophore container, starter, and control valves. Electrical activation of the cartridge starter results in a burst of hot gas to drive the turbopump assembly. Acceleration to full speed takes approximately 450 milliseconds. The pump discharge pressure rises to the point where the engine becomes self-sufficient by "bootstrapping" into the full-power level. This sequence is as follows:

Rising pump discharge pressure opens the piston-operated, main LOX valve, and the main fuel valve, both of which are spring loaded closed. As the main LOX valve opens an igniter fuel valve is actuated. This secondary valve permits fuel pressure to rupture end diaphragms of the pyrophore con-

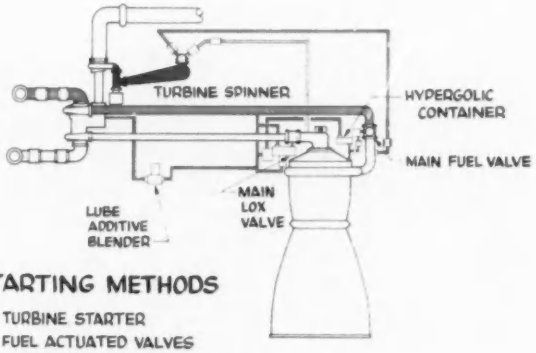


Fig. 2 — Saturn engine schematic illustrates simplification achieved in the H-1. The complex ground start system has been eliminated.

adapted from missiles

development of a huge booster was begun in 1958. Originally this vehicle utilizes a cluster of proved IRBM rocket engines

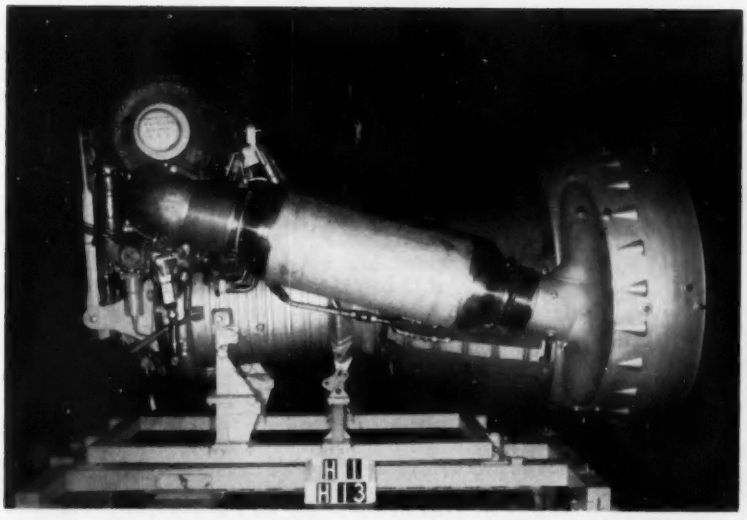


Fig. 1 — Saturn H-1 engine. The weight and envelope dimensions of the assembly are less than those of its predecessors.

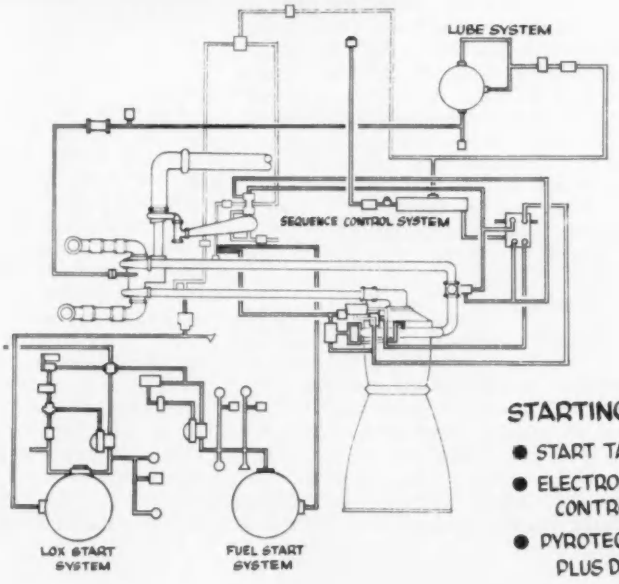


Fig. 3 — Schematic of the Jupiter engine, from which the H-1 was partly adapted. The complex start control system is eliminated on the H-1.

FEBRUARY, 1961

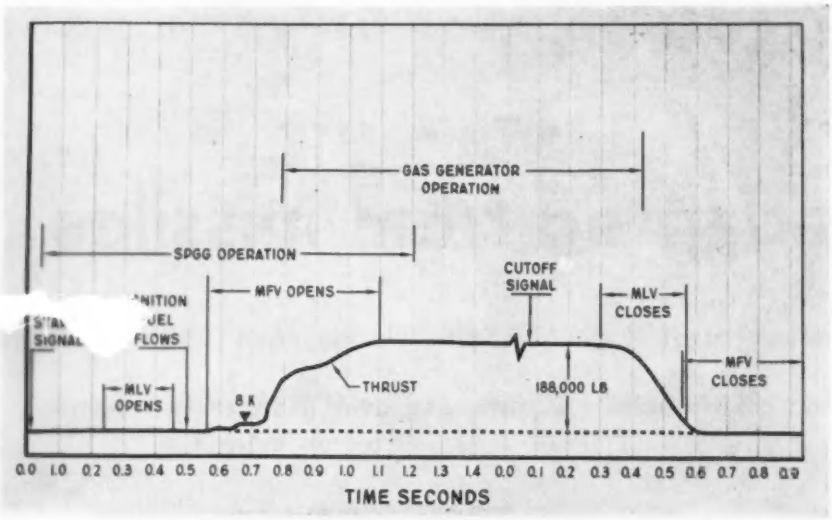


Fig. 4 — Sequence of H-1 operation. The engine reaches mainstage operation considerably faster than previous engines do.

Saturn engine adapted from missiles

. . continued

tainer and forces this material through spray nozzles into the thrust chamber. This slug of pyrophoric material is followed directly by the main fuel stream, which is thus ignited. Propellant flow to the gas generator is controlled by two spring-loaded poppet valves, which are fed downstream of the main fuel and main LOX valves. If either of the main valves fails to open, the gas generator will not "bootstrap." This is a highly desirable engine safety feature.

Engine shutdown occurs when an electrical signal fires two parallel, explosive-operated valves, permitting engine fuel pressure to reach the closing side of the main LOX valve piston. The LOX valve closes; the gas generator loses its oxidizer; pump output decays; and the other valves close under spring action. Fig. 4 shows the sequence of operations of the H-1 engine.

Besides the simple circuits to fire the starting and shutdown squibs, there are a limited number of ground-powered 115-v heaters to prevent freezing of components in contact with LOX lines. These disconnect as the engine is fired.

Hardware description

The thrust chamber assembly consists of the chamber body, a propellant injector plate, and an integral liquid oxygen dome and inlet elbow. The chamber body (Fig. 5) is largely composed of type "A" nickel tubes assembled over a mandrel and brazed together. The tubes are used as flow passages for regenerative cooling of the chamber body. They are essentially round in shape at the injector end, but the contour varies in shape along the tube length to match the required geometry and heat transfer characteristics at each point. They are narrow and deepest at the minimum diameter nozzle throat and provide the highest coolant velocity here to accept the 2.5 Btu per sq in. per sec heat transfer at this point. The tube contours then gradually widen and become shallow to follow the expansion of the nozzle to its large diameter exit.

An annular fuel inlet manifold of steel connects with alternate tubes, at the upper end of the chamber. During operation, fuel passes down through these tubes, into a steel manifold ring at the exit. Here the fuel is reversed and sent upward through alternate tubes. As the fuel completes its passage it enters a third annular manifold, which connects with radial passages in the injector plate. Despite the 5700 F combustion temperature, the fuel temperature rise is less than 100 F. The fuel used is RP-1 (a narrow cut of kerosene).

Liquid oxygen is fed into the back face of the injector through a forged aluminum alloy elbow and dome. The discharge side of the injector is comprised of a series of rings, alternately LOX and fuel, each ring having a large number of slant-drilled orifices which impinge the liquids together, forming a well mixed spray. The pyrophoric compound used for engine starting is brought through separate lines to spaced spray nozzles in a ring of fuel spray nozzles, located halfway out to the injector plate periphery. In conjunction with the liquid oxygen, which is also introduced at this time, the pyrophoric establishes hollow cone flames for igniting the main fuel flow.

The tube bundle is reinforced at the combustion zone by a series of overlapping steel bands. Welded to this section are lugs and fittings to support the components, permit handling, and to accept the hydraulic actuator arms for gimbaling. The divergent exhaust nozzle is also stiffened by spaced circumferential steel bands and hoops. The nozzle contour is bell shaped and is only 80% of the length that would be required of a classical conical nozzle

of 15 deg half angle for the same 8/1 expansion ratio. The exit velocity of the combustion products is over 8500 fps.

Engine thrust is transmitted to the missile structure through a cross-bearing gimbal block of hardened steel, bolted to the top of the dome. The gimbal block, in conjunction with hydraulic actuator struts attached to the missile structure and chamber, permits the four outer engines of the cluster to be moved for directional control.

An uprated version of the Mark III turbopump used in the Atlas, Thor, and Jupiter engines is employed in the H-1 engine. The assembly consists of a two-stage pressure compounded hot gas turbine, which drives two centrifugal pumps through reduction gearing, at 4.88/1 ratio. The output of the turbine is over 3800 hp at 32,000 rpm. The pump impellers are made of aluminum and are each preceded by an axial-flow inducer. All of these elements are fastened to a common shaft. One pump feeds liquid oxygen, at – 297 F, at a flow rate of 3200 gpm, the other feeds fuel at a rate of 2100 gpm. Discharge pressures are in the 800–1000 psig range. The pump volutes are cast from a new high-strength aluminum alloy, designated Tens-50. The pump discharges are placed close to the chamber inlets, thus eliminating the relatively high pressure drops suffered with the wraparound flexible high-pressure ducting used in models where the turbopump remains fixed while the chamber gimbals.

The fuel plus additive, lubricant, and cooling liquid is pressure fed through manifolds and impinges on gears and bearings thru jets. It then passes to an overboard drain line.

The gas generator, for driving the turbine, is a small film-cooled version of the thrust chamber. For starting, a one-second burst of hot gas from a solid propellant cartridge supplies the necessary power. The steel starter case, containing approximately 6 lb of cool-burning ammonium nitrate solid propellant, generates about 1500 hp for one second.

Turbine exhaust gases are ducted overboard through a heat exchanger, which vaporizes a small flow of LOX to form gaseous oxygen for pressurization of the missile LOX tanks. The outboard engines have an annular aspirator around the chamber nozzle exit into which these exhaust gases are dumped. The exhaust gases of the nongimbaled inboard engines are ducted radially outward through the missile skin, then redirected axially by an elbow.

The H-1 engine has excellent potential for further simplification and thrust uprating. An advanced model, designated the H-2, is on the drawing boards. This engine may utilize a direct-drive turbopump and eliminate the entire gas generator system by employing gases bled off the main thrust chamber to drive the turbine. In approximately the same physical envelope and having approximately the same weight as the H-1, this advanced model is intended to develop 250,000–300,000 lb of thrust. This would raise the total thrust of an 8-engine cluster to 2–2.4 million lb.

To Order Paper No. 242A . . .
from which material for this article was drawn, see p. 6.

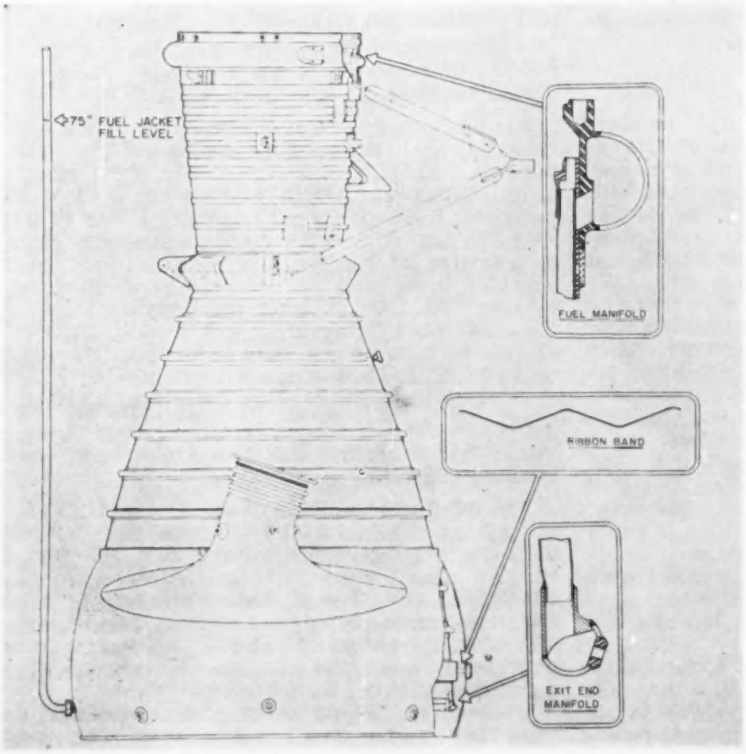


Fig. 5 — Thrust chamber body of the H-1 engine. Regenerative cooling of the chamber raises the fuel temperature less than 100 F as it makes two passes through the tubes that compose the wall.

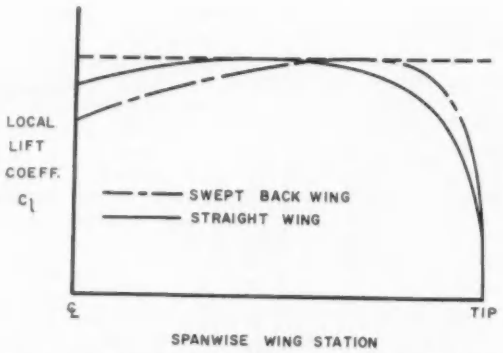


Fig 1 — Typical spanwise lift distribution at high angles of attack for a straight and a swept wing.

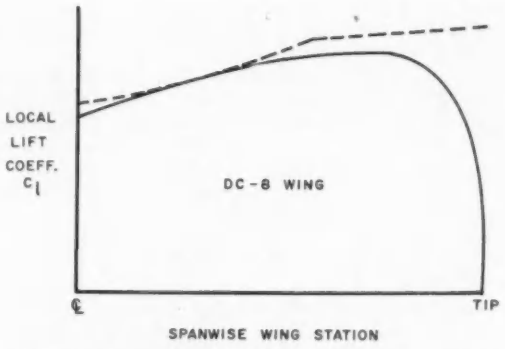


Fig. 2 — DC-8 concept of spanwise list distribution. Swept wing stall problem is solved by lowering lift capability of inboard wing section to insure that this area stalls first.

Flight characteristics

Based on paper by

Orville R. Dunn

Douglas Aircraft Co., Inc.

ALL jet transports are fast, quiet, and comfortable, but their flight characteristics are by no means identical. The flight characteristics of the DC-8 are here described by reference to key design concepts and engineering developments.

Wing design

At the outset, cruise requirements and the state of the art dictated a relatively thin wing of approximately 35 deg of sweep. But the aerodynamic, structural, and dynamic difficulties associated with such a wing prompted efforts to get the desired cruise Mach number with minimum sweep and maximum thickness. A 30-deg sweep was chosen and airfoils were sought to satisfy design requirements.

Many conventional airfoil sections were found to give the required high-speed performance but they had relatively poor maximum lift capability. They were deficient even for straight wings and the effects of wing sweep only compounded the problem, which is shown by Figs. 1 and 2. Typical spanwise lift distributions at high angles of attack for a straight and a swept wing are shown in Fig. 1. The dashed line shows the usual distribution of airfoil maximum lift capability along the span. The swept wing loads up more rapidly near the tip and practical amounts of washout are ineffective in eliminating it, hence a conventionally designed swept wing will exhibit tip stall. This leads not only to a complete loss of lateral control in the stall, but to a violent pitchup as well.

One solution to the stall is to lower the lift capability of the inboard wing sections to insure that this area stalls first (Fig. 2). It became possible to use this method when we developed a high drag divergence Mach number airfoil for the outer panel which had even higher than normal maximum lift capability. With these panel airfoils the required reduction in inboard airfoil maximum lift capability can be made without unduly compromising the total wing maximum lift. Thus, the DC-8 has three airfoil sections (Fig. 3). The DSMA 87 and 88 are the outer panel airfoils having the extremely high lift capability in combination with a high drag divergence Mach number.

Airfoil sections

The mid-semispan station, DSMA-87, has a relatively flat top in the crestline area and a blunt leading edge. The airfoil is 10.2% thick. The inboard airfoil, DSMA 128, which controls the stall, could have been a sharper nosed version of DSMA 87 if it were not for the root interference effects, particularly at high Mach number, which result in a loss of effective sweep and an increase in aerodynamic camber. The inboard airfoil was designed to cancel these adverse effects and control the stall. The resultant wing had the desired high drag divergence Mach number, good maximum lift capability, and stall characteristics the same as those of a straight wing.

Leading-edge slots

The DC-8 was designed to operate with nacelles and pylons attached to the wing, and their adverse high-speed interference effects were eliminated through careful design, which included cambering the pylon. Nevertheless, their mitigating effect on the stall characteristics of conventional swept wings was still in evidence and the $C_{L_{max}}$ loss associated with these pylon effects nullified much of the $C_{L_{max}}$ gain inherent in the basic wing.

The solution to this problem was to incorporate wing leading-edge slots just inboard of each wing-

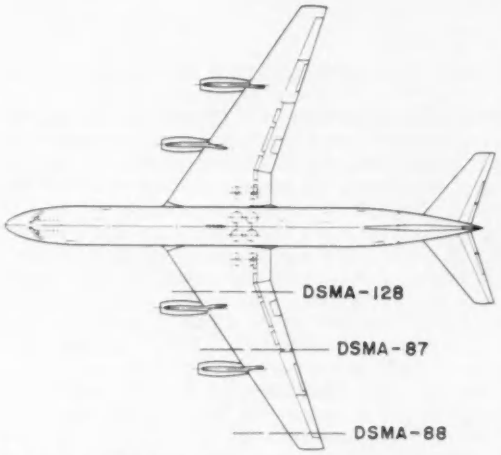


Fig. 3 — Three airfoil sections of DC-8 wing. Outer panel sections have extremely high lift capability in combination with a high drag divergence Mach number.

of the DC-8

pylon intersection. The slots are open only when the flaps are deflected. With flaps up, the slots are sealed off on both the upper and lower surfaces by flush doors. With slots open, the stall characteristics are essentially those of the basic wing.

Horizontal tail

The horizontal surface was designed with great care to minimize any adverse compressibility effects. The design philosophy was simply to make the tail less critical than the wing. The tail surface is swept 35 deg — 5 deg more than the wing — and uses special Douglas airfoils. It is placed at the extreme rear end of the fuselage where the velocities are less than freestream. Longitudinal trim is accomplished by an adjustable stabilizer. A relatively small chord elevator precludes adverse hinge moment effects at high Mach number.

The elevator is equipped with an elliptical nose overhang balance of approximately 35% chord, which has proved very successful at high Mach number. Fig. 4 shows that at an airplane Mach number of 0.96 there is no essential change in the hinge moment characteristics from those at Mach number 0.2. Each curve covers an elevator and tab deflection range of interest for the corresponding Mach number of operation. These characteristics have been verified by FAA dive tests to a true Mach number of 0.97.

Elevator control

As originally conceived, the elevator was driven aerodynamically with a single, long-span control tab on each elevator. A zero link ratio or pure flying tab control system was used with suitable springs. Early flutter analyses, however, showed the long-span tab to be affecting flutter characteristics detrimentally. Moreover, a smaller control tab would not drive the

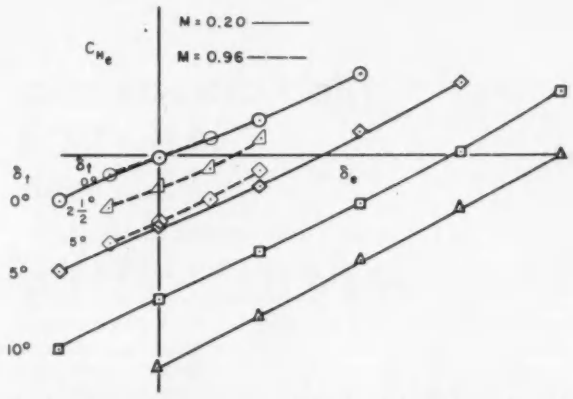


Fig. 4 — Elevator hinge moment coefficients of the DC-8 at low and high Mach numbers.

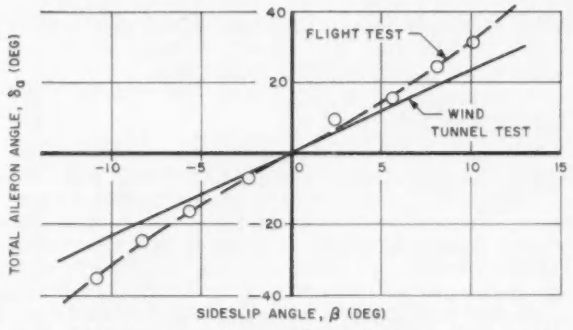


Fig. 5 — Aileron angles required in landing sideslips as shown by flight data and wind tunnel test.

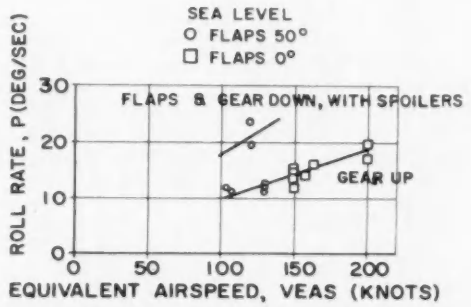


Fig. 6 — Measured roll rates at low speeds for DC-8 with and without spoiler operation. At normal approach speeds, roll rate is nearly 25 deg/sec.

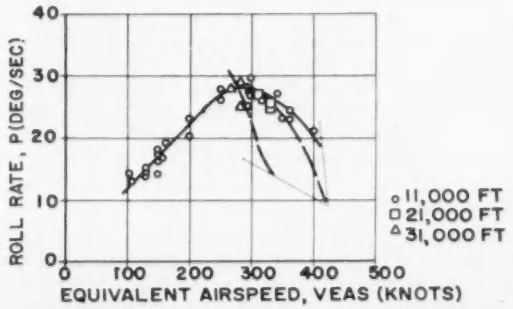


Fig. 7 — DC-8 high-speed rolling performance at three altitudes.

Flight characteristics of the DC-8

. . . continued

elevator to full travel under critical control conditions.

The solution here was to split the tab into two pieces. The inboard section was retained as the control tab and the mechanical advantage over it was cut in half. This reduction kept the original aerodynamic force levels at the cockpit, and converted the system to a linked tab control wherein the pilot has control over both the tab and the main surface. As a consequence, the control system could be simplified and the tab-to-elevator ground control spring eliminated. The outer piece of the split tab was converted to a geared tab with a motion approximating that of the original control tab under critical maneuvering conditions.

Lateral controls

The large DC-8 rudder was shown to provide excellent crosswind landing capability, but in so doing it introduced a lateral control problem. Fig. 5 compares wind tunnel test and flight data to show the aileron angles required in sideslip. It also shows lateral control to be insufficient for the full effective use of the rudder. This was an intolerable situation. Although directional and longitudinal controls are attitude controls, an airplane's lateral control system is a rate control and it is imperative that its limits not be exceeded when the airplane is in equilibrium at its maximum attitude.

The excesive aileron deflection requirements indicated by the flight data implied either a low aileron effectiveness or a higher wing dihedral effect than that shown in the wind tunnel. Study of related flight data then brought the conclusion that a higher dihedral effect was responsible, although the wind tunnel discrepancy has never been explained.

Changing the wing dihedral was out of the question, but it was a simple matter to add a lateral control function to the ground spoilers. These spoilers function as a lateral control device only when the landing gear is down and when aileron deflections greater than half throw are required. In addition to making possible the full use of rudder capabilities in crosswind landing, the spoilers brought about greater low-speed roll control (Fig. 6).

The superiority of ailerons for lateral control near and at the stall is without question. Spoiler controls have the advantage that they can be placed in the same spanwise position on the wing as that occupied by the wing flap. Since the more inboard position of any lateral control device is an advantage at extremely high dynamic pressure, due to the smaller loses associated with wing aeroelasticity, spoilers are advantageous at high speeds.

Aileron features

High-speed, lateral control capability on either the power or manual systems is improved by what is called a torque-coupled, split aileron. The aileron is divided into two sections. The outboard section is coupled to the inboard one through a preloaded torque link. The drive system is on the inboard aileron.

Operation is quite simple. At low speeds, where the aerodynamic hinge moments are less than the torque preload, the two sections operate as a unit to provide a very powerful control device in this critical region. At high speed the hinge moments on the outboard aileron exceed the preload at successively decreasing aileron deflections as speed is increased. Beyond this preload limit, the outer aileron ceases to deflect and the system approaches that of an inboard aileron control only. This minimizes the deleterious effects of aeroelasticity without the complication of shiftover or lockout devices.

At the maximum limit speed of the DC-8, roll rates are always equal to or greater than 10 deg/sec (Fig. 7). They could be less than this and still retain adequate control, but the higher level was designed into the airplane as a precautionary measure.

Recent modifications

The basic DC-8 wing was designed for operation at lift coefficients of approximately 0.3. Flight tests verified the basic characteristics but also showed a higher than desired drag when operating at the higher lift coefficients corresponding to long-range cruise conditions. Several steps were then taken to reduce this high-lift, high-Mach-number drag. One change made was a revision of the wing tips to alter the local flow effects which decrease the effective sweep at their tips.

Another change was to modify the leading edge of the airfoils. The original airfoils were designed to allow high nose pressure peaks when operating at high lift coefficients in the high-Mach number, long-range cruise condition. When it was determined that the earlier drag rise at high lift coefficients was associated with these nose pressures, new leading edge shapes were designed. And since it was recognized that the modification would reduce the maximum lift capability of the airfoil, a small extension in the chord was introduced to compensate. This required some redesign of the slots. Flight tests show the new wing to have the same maximum lift capability as the old and a significantly reduced drag in the high lift coefficient region.

Flight characteristic gains

The new leading edges have improved the flight buffet boundary. At a representative gross weight and cruise altitude, the buffet onset occurs at a Mach number of about 0.88, builds up to a maximum intensity of approximately 0.92, and disappears almost completely at 0.94. Improved buffet characteristics have raised the maneuver capability limits as well. For example, at the heavy weight, initial cruise condition, a 1.6 g turn can be made at a Mach number of 0.82 before onset is reached. The better boundary also allows operation at altitudes about 2000 ft higher without buffet than was possible originally.

The revised leading edges are also responsible for reducing the already mild transonic tuck to two-thirds of the force levels shown originally. As an outcome, the Mach trim compensator system has been further simplified.

To Order Paper No. 237A . . .
from which material for this article was drawn, see p. 6.

Material drawn from an
SAE Detroit Section Paper

Mortality curves spot reliability problems

Auto industry takes a cue from insurance companies —it uses mortality curves to pinpoint failure rates of complex apparatus. Case histories show how reliability can be improved.

Based on paper by
A. J. Hofweber
General Motors Corp.

MUCH of the measurement and analysis of the reliability concept is based on statistical probability theory. Industry has borrowed the mortality probability curve from the insurance statistician and uses it to describe the failure rates of complex apparatus (Fig. 1).

In terms of population mortality, the initial rise of the curve can be described as prenatal, the next peak as infant mortality, then the leveling out in the adolescent and middle-age section is followed by the period of old age, where the curve again rises.

This corresponds to failure rates of mechanisms that fail in prototype tests or during manufacture — the infant mortality type of failure at the initial period of use, the haphazard and accidental type of failure, and finally the eventual wearing out. Analysis of reliability in the automotive field reveals that the major hope for improvement is in the infant mortality range.

Reliability method of operation

The first place to attack the infant mortality problem is in the engineering department. At Ternstedt Division of GM, the Product Engineering Section has been organized according to the systems concept. The staff engineer in charge reports to the chief engineer and supervises five engineering groups. Group 1 works on exterior moldings, treating the combination, for example, of moldings around a body opening as a composite system. Group 2 is assigned interior moldings and trim items. Group 3 covers three types of items — hinging, seat mechanisms, and seat springs. Group 4 covers window mechanisms, including regulators, windowframes, ventilators, and related components. The fifth group is assigned to latching mechanisms, treating the outside door handle, latch striker, remote control connectors, and interior handles as a composite single subsystem.

Coordinated with these engineering groups, the design section, cost analysis group, and various other sections are subdivided to correspond.

A reliability review on a design in the proposal stage is conducted by a group consisting of the product, design, test, cost analysis, and reliability engineers. The design is evaluated for soundness

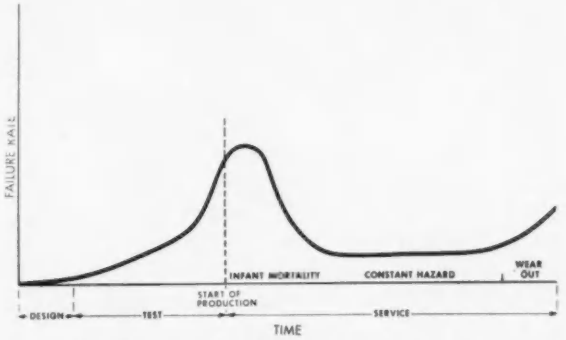


Fig. 1 — Mortality curve showing types of failure considered in realiability program.

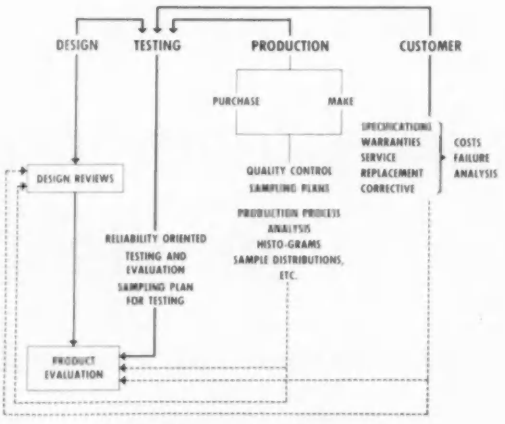


Fig. 2 — Design reliability feedback loops.

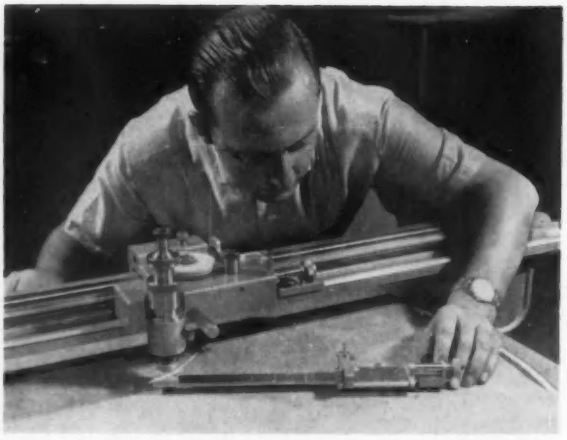


Fig. 3 — Two-dimensional scriber improves accuracy of templates, checking fixtures, and die models.

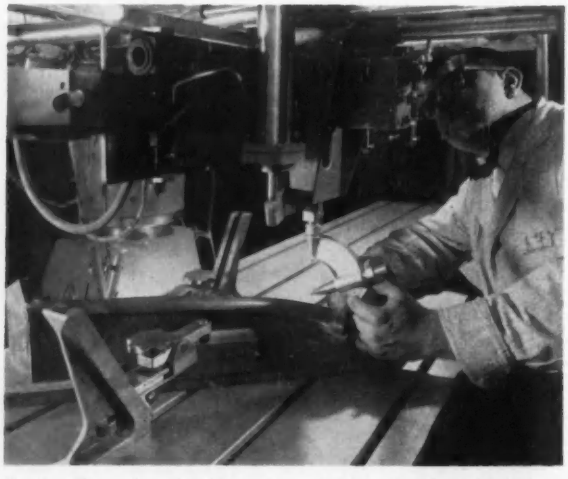


Fig. 4 — Three-dimensional tracer is used to inspect and coordinate duplicate models, fixtures, and prototypes. This permits one accurate layout to replace a number of individual layouts.

based on factors affecting reliability — such as specifications, critical areas, tolerance stackup, feasibility of manufacture, test evaluation, and, when necessary, customer concurrence.

Reliability reviews in the early stages are a means of tying together the design, test, and redesign stages. Specifics are established for future design evaluation.

The way in which the reliability review fits into the design flow of information is demonstrated by the feedback loops shown in Fig. 2. Most body hardware items require many repetitive cycles within the loops, showing the feedback of information and the refinement of design. To service the 50 active product lines encompassed by the five systems, Ternstedt has complete styling, design, engineering, and test facilities with the ability to make available ornamental and functional hardware from original inception to finished product. The evolution of the product requires the use of these facilities and their coordination through the whole development period. All these loops operate throughout the process and are responsible for satisfactory customer usage for the life of the specified article.

New developments and reliability

Progress has been made in engineering, tooling, and manufacturing that will tend to better the reliability of products. This can be shown by the following examples exemplifying scientific approach to anticipating and solving problems.

One area that long had required improvement was the accuracy of the engineering supplements on moldings such as coordinating templates, checking fixtures, and die models. An especially critical problem area occurs where a rolled section molding meets a stamped molding. To coordinate fits of this type, a precision two-dimensional scriber is used to scribe a ten-times-size master layout of the shape on parallel plate glass, using a vernier toolholder, microscope, and precise coordinates (Fig. 3). From this scribing mylar shadowgraph screen charts can be made to high accuracy by contact prints made on a vacuum frame. These mylars are used to control replica blocks for coordination on the checking fixture, as well as the tooling checks on the mating parts.

For reproduction of complex shapes of a three-dimensional nature, the three-dimensional tracer shown in Fig. 4 was developed. This device can be used to inspect and coordinate duplicate models, fixtures, and prototypes. Here, one accurate layout replaces the individual layouts normally made by several people.

By furnishing more accurate engineering supplements, tooling can be made more accurate in the initial phase, thus requiring less adjustment and fitting when the tools are ready to be used in production.

Much progress is being made in the improvement of manufacturing methods and control, and improved reliability, especially in the area of automatic assembly. The following two examples not only have improved the quality and reliability of the part, but also have saved money in the process.

Fig. 5 shows the clutch assembly operation of a window regulator as it has been done manually (left) and the same operation done by machine (right). The machine is designed to inspect its own work and reject any parts or any assemblies with mislocated or missing pieces. The ultimate lubrication performed by this machine does a far better job than was possible manually. In the manual insertion of the clutch spring, much of the lubrication was removed as it was being forced in.

Fig. 6 (left) shows the manual assembly of door lock striker components. The proper placement of the spring pin and sliding shoe is difficult to control manually. With the machine shown in Fig. 6 (right), not only is proper placement assured, but any missing or mislocated pieces are found by a probe station, which automatically rejects any defective parts.

One aspect improving reliability has been the introduction of a more rapid test for the acceptability of stainless steel for corrosion resistance. The introduction of the CASS (copper chloride acetic acid salt spray) test greatly accelerated the information that a given lot of stainless steel or that a given lot of parts was acceptable from the corrosion resistance standpoint. The time gained resulted in considerable improvement in the quality of incoming raw material, as well as the quality of moldings being shipped.

The CASS test is now being supplemented with an additional check in which a drop of specially prepared solution can give an immediate answer as to the stainless steel acceptability. In all testing, the sooner that the knowledge of acceptance or failure can be transmitted, the sooner corrective action can be taken.

These improvements indicate that continued application of these principles will result in even greater improvement of component reliability, resulting in improved reliability of the body as a whole and the automobile as a complete vehicle.

To Order Paper No. S262 . . .
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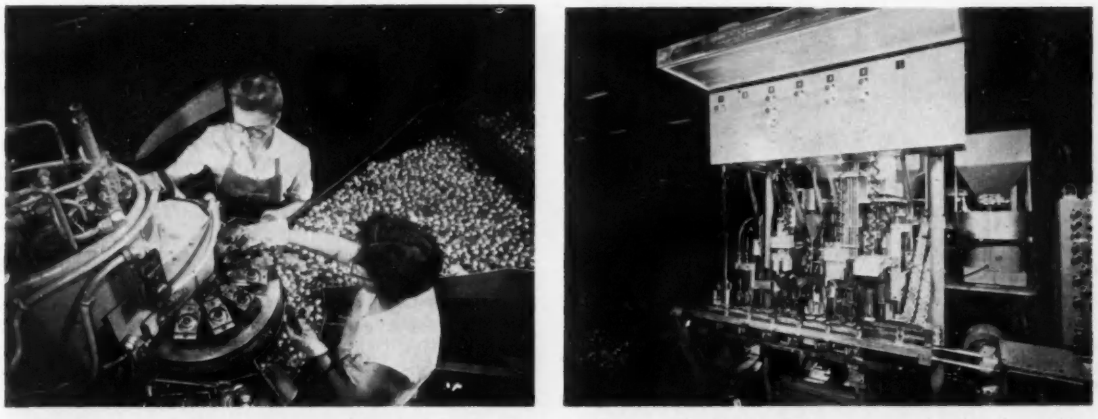

Fig. 5 — Clutch assembly operation of a window regulator as it has been done manually (left) and the same operation done by machine (right). The machine inspects its own work and rejects any parts or assemblies with mislocated or missing pieces. The ultimate lubrication performed by this machine does a far better job than was possible manually.

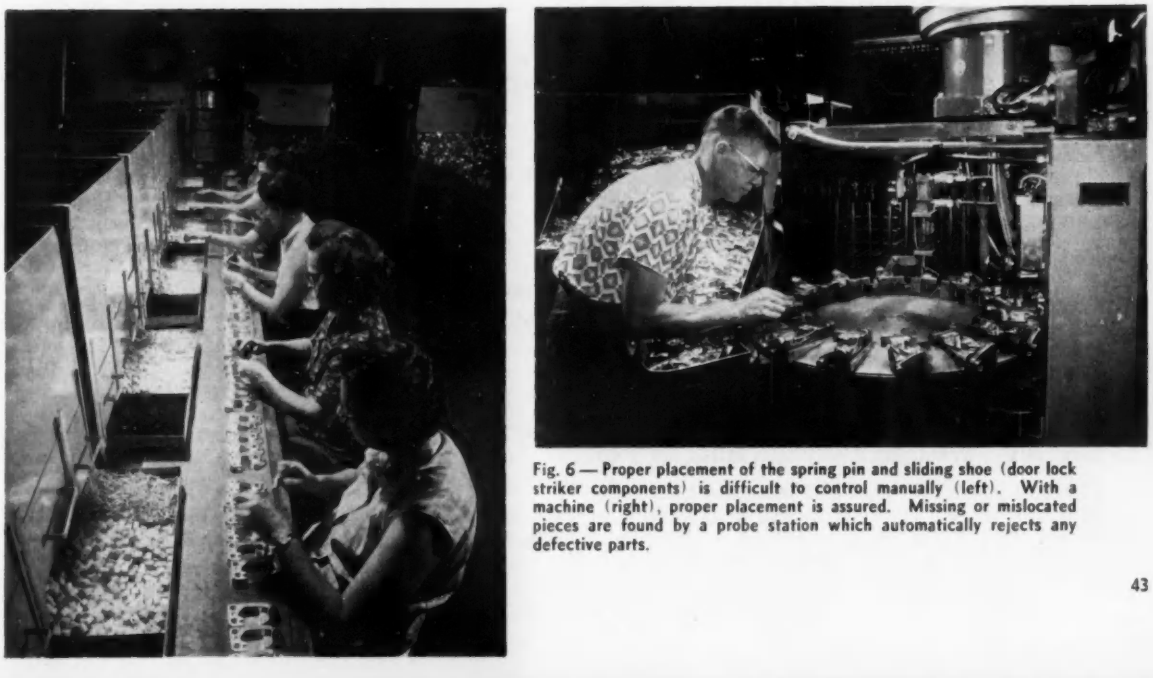

Fig. 6 — Proper placement of the spring pin and sliding shoe (door lock striker components) is difficult to control manually (left). With a machine (right), proper placement is assured. Missing or mislocated pieces are found by a probe station which automatically rejects any defective parts.

Tomorrow's buses

predicted from today's trends

Based on paper by

E. N. Hatch

Nassau County Department of Franchises

BUSES in the United States will continue to grow in number at about the same rate as the country's population . . . which means about 17–18% in the next decade. There will continue to be a bus for every 630–640 people. To provide these additional bus registrations, total bus production will average between 22,000 and 25,000 per year during the period. (See Figs. 1 and 2.)

These are two of some 20-odd predictions which can properly be made from a mass of recently compiled data on past, present, and future bus trends.

Other reasonable predictions about bus transportation in the 1960–1970 decade stem from these data as follows:

City (or transit type):

- Average yearly production will be between 2000 and 2500 per year.
- Cents-per-mile operating and maintenance expenses will continue upward. Average cents-per-mile revenue for city bus companies in the New York area is around $1.16; average operating expense approximately 95¢.
- From 1948 through 1955 there was a fairly fast rate of decline in the number of city bus passengers . . . but the number carried in the larger cities will remain nearly constant — with possibly some increase.
- The recent decline in local transit bus miles will level out — averaging 1½ billion miles per year.
- Size of the transit-type bus will continue to increase — to an average seating capacity of 47–49.

Intercity

- Cents-per-mile operating expense for this type of operation varies with the size of company and the geographical area. The upward trend for all average intercity buses will continue with the increase in labor cost — from approximately 50¢ per mile in 1960 to well over 60¢ in 1970.
- Cents-per-mile revenue will continue from the present average of around 55¢, to well over 70¢ by 1970.
- Average cost will continue to rise from $40,000 to $50,000 for those buses with over 35 seats — with increasing demand for air conditioning.
- Average yearly production will be between 1000 and 1500 per year.
- Bus miles forecast — a little over 1 billion per year.

City-Suburban

- The upward revenue-per-mile trend from 65¢ will continue to nearly 80¢ by 1970 — with corresponding increase in operation and maintenance expense.
- While there has been a decline in the total number of miles operated, there is an encouraging increase in the number of school and charter bus miles operated by these companies.

School Buses

- Outstanding in the bus field is the rapid growth since 1920 in the use of school buses for public school student transportation. Today, 35% of these students are being carried by school buses; by 1970, the figure will be around 45%.
- The production trend, therefore, will continue upward — between 20,000 and 22,000 per year. (See Fig. 3.)

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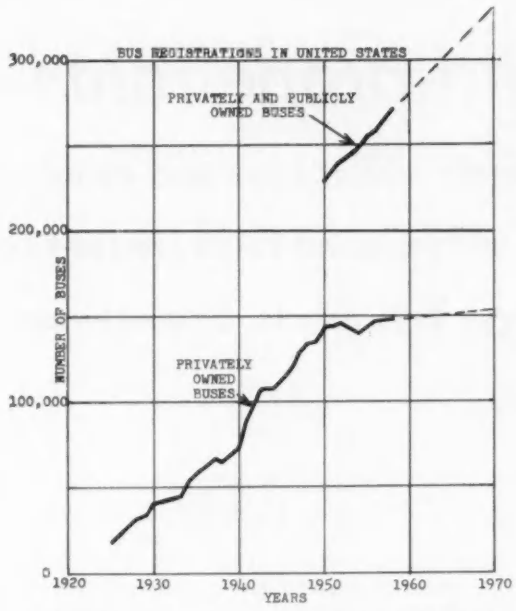


Fig. 1 — Top curve shows the number of privately and publicly owned bus registrations in the U. S. since 1950; lower curve, the number of privately owned registrations since the mid-1920's.

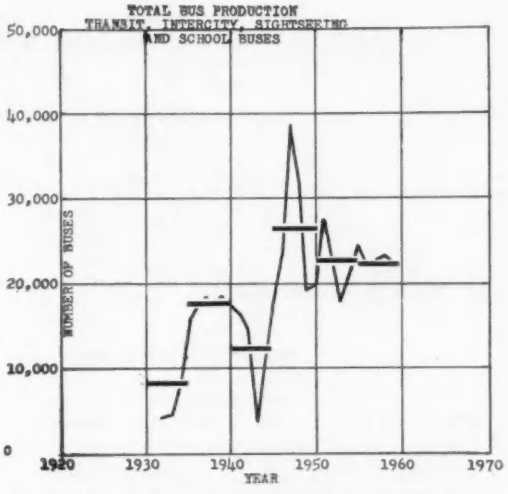


Fig. 2 — Yearly production of all types of buses since the early 1930's is shown here — with a five-year average. The war years — 1942–1945 — show the sharpest drop; 1947 and 1948 the peak. Yearly average in 1950 through 1959 was 22,670.

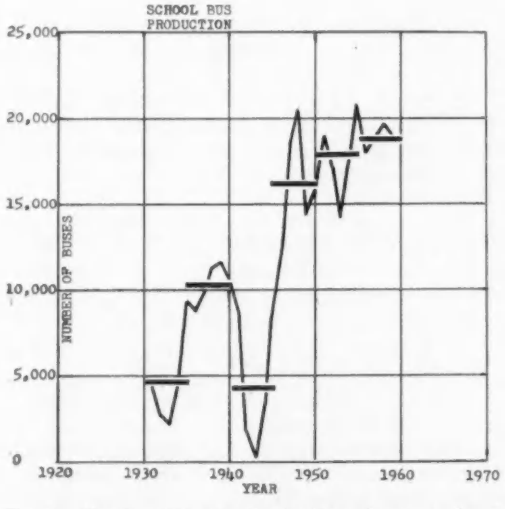


Fig. 3 — Rise in production of school-type buses, as shown here would indicate an average yearly production of between 20,000 and 22,000 during the next decade.

AUTHOR "BING" HATCH has been studying bus operations — and improving their efficiency — for more than 30 years. Bus operations of every type — transit, intercity, school — have profited from his recommendations during this period.

His studies of motor vehicle operations have extended far beyond his normal job responsibilities throughout his engineering career. In the late '40's he made a special study of vehicle operating conditions in Boston, San Francisco, Yonkers, Montreal, and many other cities for the New York City Transit System . . . and in 1959 — on leave from his position as Director of Transportation and Franchises. Nassau County, N. Y. — he participated in an exhaustive study of public transportation systems in Caracas, Venezuela.

Hatch served as chairman of important government technical committees having to do with transportation during World War II and has presented many technical papers before SAE and other engineering bodies. He is a past SAE director and a past-chairman of SAE's Metropolitan Section.

solid propellants—

. . . have both advantages and problems when used with ground-to-air, rapid-firing missile systems. This article discusses both.

Problems in solid propellant use . . .

DESPITE their many desirable characteristics, solid propellants pose certain problems when used with ground-to-air, rapid-firing missile systems. Among the more important are:

- Effect of propellant burning temperature on component performmance.
- Effects of propellant residue.
- Proper utilization of heat sinks.
- Tighter processing controls on propellant.
- Rapid boost reqirements of the grain and hardware.

THE EFFECT OF PROPELLANT BURNING TEMPERATURE on component performance is a problem because the energy of the solid propellant is usually converted into electrical or mechanical form. Usually this conversion is through turbine drives at relatively high speeds and close tolerances.

The practical limitations of the materials used in these applications become more critical for these applications.

THE EFFECTS OF PROPELLANT RESIDUE are a problem because propellant residue often plugs nozzles and binds turbines. "Clean-burning propellant" is a common expression heard when considering solid propellants as a source of energy for military power systems. Nozzle areas and turbine clearances are sensitive to even, clean-burning propellant residue.

PROPER UTILIZATION OF HEAT SINKS can improve or degrade gas generator efficiency. Heat losses occurring between the source of generation and utilization will result in larger gas generator requirements and complexity of controllers.

TIGHTER PROCESSING CONTROLS ON PROPELLANTS are required when gas generators are used for auxiliary power supplies. Tighter tolerances are needed because these auxiliaries must supply continuous, instantaneous power with minimum as well as maximum outputs over the flight duration of the missile.

The effects of the propellant burning rates with the ambient temperature become more critical and dictate the grain configuration as well as the composition.

RAPID BOOST REQUIREMENTS ON THE GRAIN AND HARDWARE pose a difficult problem. The rotational mass of the auxiliary power supply must be accelerated in a short period of time. The boost charge, which is usually integral with the gas generator, quite frequently is required to supply 5–10 times the average mainstage power.

Boost requirements are reflected also in the hardware design. The initial burning surface of the mainstage propellant is quite often machined to close tolerances to perform either all or part of the boost function.

NONE of these problems is insurmountable . . . but all require solution to permit entirely successful use of solid propellants in ground-to-air, rapid-firing missile systems.

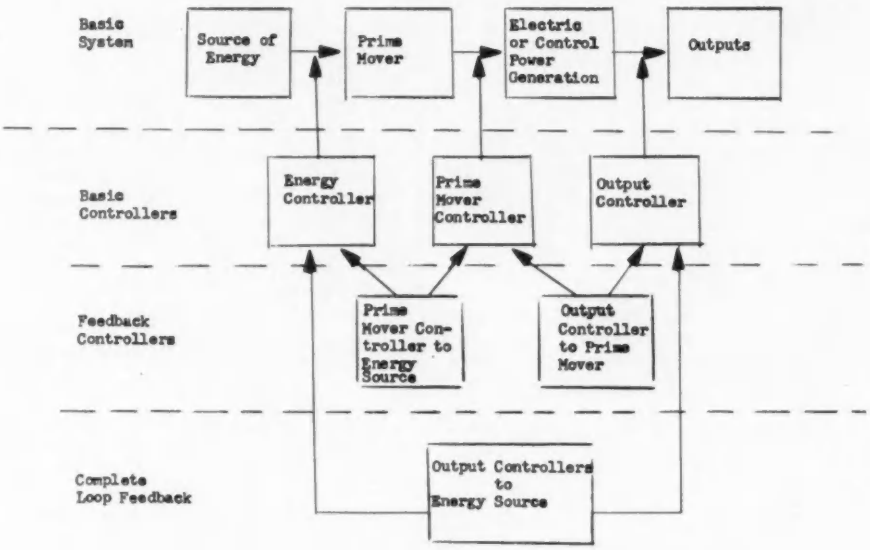


Fig. 1 — **Block diagram of auxiliary power system combinations.**

Based on paper by

Michael Voytish, Jr.

Convair Division, General Dynamics Corp.

SOLID PROPELLANTS have much to offer to ground-to-air rapid-firing missile systems. But to get the best out of them, their disadvantages must be circumvented — and propellant, components and system must be compatible with the overall missile weapon system. Solid propellants are, in fact, already being used successfully in rocket engines for propulsion on several rapid-firing, ground-to-air missiles.

The block diagram in Fig. 1 illustrates some of the system combinations that can or may be required to be compatible with the missile weapon system.

The secondary or auxiliary power system more commonly known as the APS is required to furnish the electrical power for guidance and usually hydraulic power for control. Hot gas servo systems have been used successfully in certain applications, thereby eliminating the hydraulic power energy conversion and components.

Better understanding of a solid propellant APS system will result from a general discussion of Fig. 1 and component characteristics:

1. Basic System

The basic system is comprised of a source of energy, a prime mover or movers, and appropriate means of conversion of power to electric or control power (hydraulic) generation to be supplied as outputs to the missile requirements.

Source of Energy — Solid-propellant gas generator.

The solid-propellant gas generator consists of a structural case with appropriate insulation, a squib igniter, a boost charge, mainstage propellant charge, a nozzle, and a standpipe or filter to the entrance of the nozzle.

Parameters which must be considered and understood in the gas generator design are:

a. Propellant flame temperature.
b. Gas residue and deposits.
c. Ignition and boost control.
d. Burn rate magnitude and variation with pressure.
e. Burn rate sensitivity to soak temperature.
f. Effects of mechanical and climatic environments on propellant performance.

Prime Mover — Can be a piston, turbine, or hot gas engine, either vane or piston type.

In general it can be said that the hot gas engines are more efficient and run at lower speed. The boost charge requirements are usually lower also. These units are more susceptible to the propellant residue.

The turbines are usually more effective at high speed and result in lower weight. The operating speeds are in excess of those available for power-

solid propellants—

. . . continued

generating equipment, such as pumps and alternators, and require the necessity for gearboxes.

For low power applications in hydraulics, hot gas generation for displacement of a piston expulsion system can be very effective.

Electric or Control Power Generation

Electric Power Generation of present missiles are predominantly 400 cps. This limits alternator speeds to 24,000 rpm. Higher efficiencies and lower weights can be achieved by going to higher frequency alternators.

Hydraulic Power Generation of present systems has been limited to practical speeds for pumps. Reliable pumps are available to 12,000 rpm and are in production, pumps up to 24,000 rpm are in limited production at this time, which will increase system efficiency. Various pump designs have been proposed to run at higher speeds and some units have been made. Any further developments of a reliable pump at these higher speeds will see higher system efficiency, provided they are also economical.

Outputs

Intimate detail knowledge of the output requirements and tolerance requirements dictates the system approach and controllers. Important parameters of the electric system are voltage regulation, frequency, power, and harmonics. Important parameters for the control system are torque, rate, response, system stiffness, leakage, resolution, and duty cycle. In hydraulic systems, heat sinks are also important.

2. Basic Controllers

Energy Controller

Energy controllers on present solid-propellant gas generator are in the form of blowout discs, relief valves, and pressure regulators. The design range of the system can be improved with these devices; however, complexity is increased. Hot gas relief valves are effective at higher pressures. Pressure regulation at the lower pressures cannot be held reliably over large changes of mass flow because of contamination and valves sticking.

The percentage of error at pressures below 500 psi for valves now available over mass flow rates of cutoff to one third the gas generator flow are anticipated to be in the 10–15% regulation range. Pressure regulation of 5% can be accomplished with pressures of 1500–2000 psi.

Prime Mover Controller

These have not been effectively used with solid propellants because of propellant residue. Some gas engines have incorporated flyball speed governors. Prime mover controllers have been more effective in other types of prime movers, such as electric motors.

Output Controllers

Output controllers are effectively used as parasitic dissipation systems. These types of controllers do not require component designs which have to work in the hot gas environment. Examples of these controllers are parasitic alternator and its control loop for electric and flow regulator for hydraulic systems. System efficiencies, weight, and cost are poor with these types of controllers; however, they do offer the advantage of test ability and are free of the hot gas environment.

3. Complete Loop Feedback

Output Controllers

. . . to energy source offer the most for reduced systems weight and cost with improved system efficiencies. These controllers accept their error signals from outputs such as frequency, voltage, pressure, speed, or flow and are then amplified to drive a regulating valve or bypass valve on the gas generator or turbine inlet.

Variations in solid propellant and component performance can be masked out by this approach.

One method of utilizing a solid-propellant power supply was to utilize a parasitic dissipative system. It is actually two independent systems, hydraulic and electric. The electric system is comprised of a solid-propellant gas generator, a turbo-alternator assembly that has three alternators on a common shaft, a speed control unit (frequency discriminator) and a parasitic load. The turbo-alternator assembly runs at a speed of 24,000 rpm.

The hydraulic system is comprised of a solid propellant gas generator, a turbine gearbox pump assembly, and a hydraulic flow regulator, which supplied hydraulic power to an essentially fixed load. The turbine runs at 36,000 rpm and the gearbox has a 3/1 ratio with a resultant pump speed of 12,000 rpm.

The disadvantages of this hydraulic-electric system are:

1. High weight.
2. High cost.
3. Operating temperature range for parasitic capability.
4. Tight performance requirements of gas generator.

However, there are advantages to this system:

1. No hot gas components required.
2. Testability of the major portion of the system.
3. Utilization of straightforwardly designed components.
4. Early incorporation into production of a feasible solid-propellant system.

To Order Paper No. 232C . . .
from which material for this article was drawn, see p. 6.

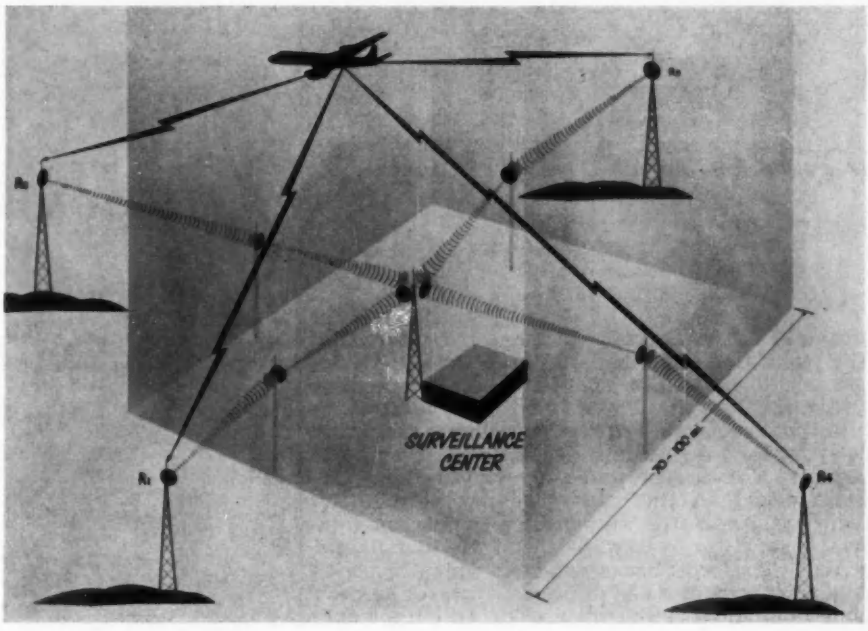


Fig. 1 — Receiving stations placed around a 70- by 100-mile LOCTRACS sector transmit coded impulses to a surveillance center.

LOCTRACS

. . . An answer to high-density air traffic control

Based on paper by

Paul F. Pearce

Lockheed Electronics Co.

System Characteristics

Sector Spacing, miles	70 to 100
Capacity per Sector	1,000 + aircraft
Data Rate per Aircraft, times/min	
Position	600
Identity and Altitude	35
Resolution (Basic), mile	1/6
Airborne Equipment (estimated)	
Weight, lb	3–5
Size, cu in.	200
Transmitter Power	
Average, microwatts	55
Peak, watts	5
Bandwidth, megacycles	2
Frequency	Not critical

A SMALL, pulse-coded, airborne transmitter beaming to four receiving stations placed around a rectangular sector 70 by 100 miles, plus a surveillance center to which the receiving stations transmit information . . . these are the features of LOCTRACS, a traffic control system capable of handling over 1000 aircraft per sector.

The airborne installation is inexpensive, weighs from 3 to 5 lb, and is effective with *all types* of aircraft. From it, pulse sequences are beamed independent of other aircraft transmissions in the area. No synchronization is required between aircraft or between aircraft and ground. Because each transmitter functions automatically, no burden is placed on the pilot, thus eliminating the need for aircraft rollcalls.

The ground receiving stations (as shown in Fig. 1) feed the pulse sequences to a sector surveillance center, which computes the position, altitude, and identity of each plane to within 1/6 mile. Thus, the system is applicable to terminal areas as well as to en route traffic control.

How it works

A pulse is transmitted to four remote receiving sites in a sector with time delays at each site pro-

LOCTRACS

. . . continued

portional to the aircraft's distance from that site. The set of time differences between these time delays is unique for each point in the area of the sector. Thus, it is possible to bring these four pulses into time coincidence at the surveillance center by delaying each an amount proportional to the distance from an aircraft to the receiving station. Unequal delays in the microwave paths from the remote sites to the surveillance center may be compensated for by fixed delays at the surveillance center. The coincidence detector, which responds only when a pulse is simultaneously present on each of its four input lines, will provide an output only when an aircraft is present at that point in the sector.

In practice, the delay lines are binary-shift registers driven by a common clock with the output from each stage corresponding to a tap of the delay line. The clock rate then defines the time interval that can be resolved and, correspondingly, the size of a surveillance element of the sector. Thus, an aircraft anywhere within a given volume of space (surveillance element) gives rise to an output from the coincidence detector. The pulses transmitted from the aircraft must, of course, be equal to or less than the clock period to achieve the desired resolution. A 1-megacycle clock rate and 1-microsecond transmitted pulse width result in approximately 1/6-mile resolution.

Data input

Altitude information is provided by a digital pickoff from a barometric capsule, and identity information, by a fixed code established when the equipment is installed in the aircraft. A third information input to the airborne station, which is optional, is a canned message unit that can provide selection by the pilot of a limited amount of routine additional data. These two or three digital data inputs to the system are sampled sequentially by the coder, which also generates a start pattern at the beginning of each message sequence. The output of the coder then provides on-off modulation to the transmitter, which, in turn, generates a pulse of the required duration for each of the "on" conditions of the coder. The transmitter is continuously monitored by an alarm circuit, which provides an indication to the pilot that the equipment is operating properly and that his aircraft is participating in the air traffic control system.

To order Paper No. 243B . . .
from which material for this article was drawn, see p. 6.

Key to jet is community

Based on paper by

Bart Spano

Director, Polysonics, Inc.

MILLIONS of dollars have been spent on the problem of suppressing jet transport noise, but there is a limit to what the designer can achieve. Therefore, the pyschoacoustical approach should be employed and it should be used before community complaints snowball into antinoise leagues.

Studies made over a period of several years indicate clearly that, with careful control of the introduction of new aircraft sounds, community complaint reaction can be drastically reduced. Fig. 1 shows the listening-learning curve of communities to new aircraft sounds and portrays graphically the difference between controlled and uncontrolled introduction.

With an uncontrolled introduction, the aircraft is operated at its maximum noise level at the outset. The community cannot tell the height of an aircraft when a new loud noise is heard and it believes the louder noise to mean a lower level, with the aircraft possibly malfunctioning, perhaps heading into the community. The suspected threat to life is enough to cause widespread agitation.

How controlled introduction works

With controlled introduction, the community is exposed to a new noise at a depressed level. There are complaints even so, but they do not reach serious proportions, and they die down. At this point the noise level can be increased in the direction of normal operation. Again, a listening-learning hump takes place on the curve and again the noise level can be increased until it blends with the ambient level of the uncontrolled curve. The aircraft is now operating at normal noise level without having stirred community reaction to antinoise league state.

Community noise restrictions must be tempered with the assurance that they guarantee reductions in community complaints inasmuch as they are impediments to the air transport system. Community

noise problem psychoacoustics

IT IS NO SECRET that jet transport noise worries the industry. When the noisier turbofan is introduced we can expect an outraged citizenry to make the problem more acute.

This article tells about a method which would use the knowledge of community reaction to noise to keep public agitation within bounds.

complaint motivation is the fundamental reason for noise restriction. Therefore, careful analysis of man's noise complaint motivation or his subjective reaction to noise is necessary to establish the noise limit, which must not be exceeded in order to prevent severe community reaction.

Engine noise limitations

There has been talk of placing noise level limits on engines before they can be approved. This seems laudable, but it should be viewed with caution. A noise limit on an aircraft engine is meaningless since the combined performance of the engine-aircraft combination could, through the use of high-lift devices, get a noisy but high-thrust engine-aircraft higher above the community. This would be quieter in the community than other engine-aircraft combinations with engines of less noise and less power. However, a relative rating of the amount of noise per pound of thrust could be a handy yardstick and will indicate the relative noise efficiency of the engine.

Community noise complaint motivation is the result of the sum total of all the high intensity noises experienced by a community from an airport or airbase, that is, both flight and ground noise. Aircraft flight noise is most difficult to control because of safety aspects. This is not true of ground noise, which is also a serious problem, particularly at night, and contributes a major share to man's overall complaint motivation toward aircraft noise.

Ground runup noise can be reduced by mufflers. Available ones are not as perfect as we would like, but perhaps they will be improved over the years. Nevertheless, the need for noise control at jet airports and bases is now, and available equipment should be put to work now to relieve the ground noise portion of the airport noise problem.

To Order Paper No. 238B . . .
from which material for this article was drawn, see p. 6.

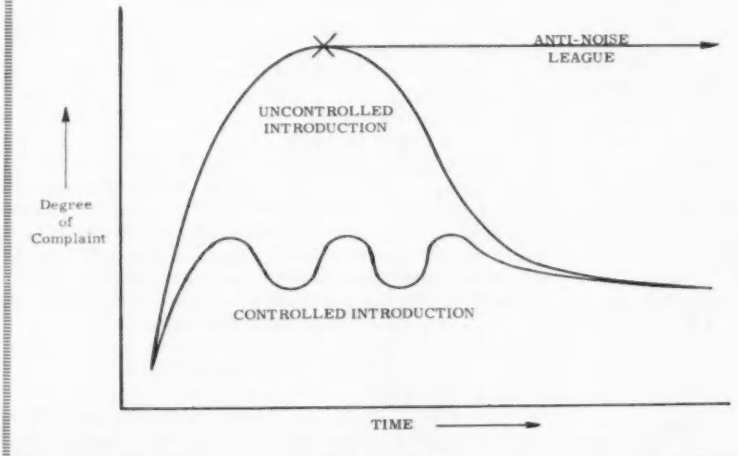


Fig. 1 — Community listening-learning reaction to new aircraft sounds. If first exposure to a new noise is made at a depressed level and the level then raised by steps as the community becomes inured, the normal operating noise level can be reached without having to combat antinoise leagues.

"Floating about in a padded cabin during a zero gravity maneuver is just plain fun."

Man's antics during zero gravity

"It's exhilarating," say the guinea pigs. When tumbling, there is no up or down and you can walk happily on the ceiling. To go from here to there—just push and float.

Based on paper by

Major Edward L. Brown

Air Force Ballistic Missile Division (ARDC)

FLOATING about in a padded cabin during a zero gravity maneuver is just plain fun. We know this from having flown over 2000 zero *g* trajectories in a C-131B transport-type airplane, which can produce about 15 sec of zero *g*. Normal walking is impossible because the friction used in ordinary walking is not present, but with practice one learns to get around. Tasks can be performed provided the subject is strapped down to give a fixed position to work from, and the speed and accuracy of arm movements is not impaired.

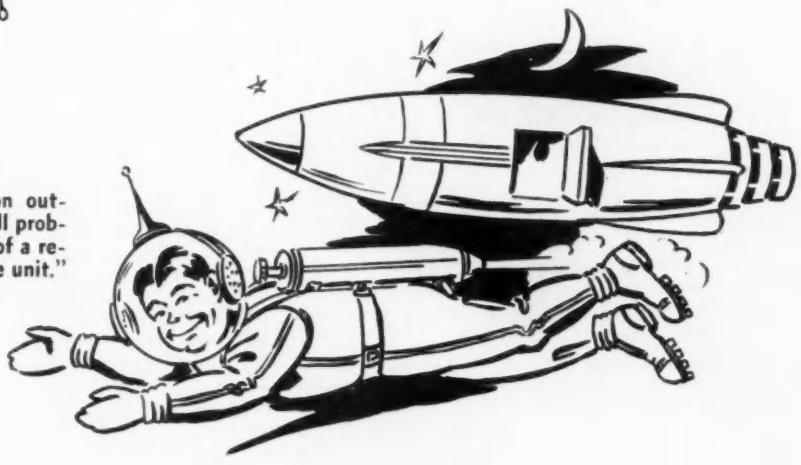
The sensation of free-floating is enjoyable and relaxing. The sensation one gets when a fast elevator starts down is not present, probably because it takes longer to get from one *g* to zero *g* than the time taken by the elevator. You have to keep pushing against the pad to test whether or not you are at zero. When a slight push starts you toward the ceiling, that's zero. Novice flyers may suffer attacks of nausea, due probably to the changing *g* rather than to the zero *g*.

Travel inside a space vehicle

Two ways of getting around inside a space vehicle have been studied. One is to push off walls, floors, or ceiling to float; the other is to walk with magnetic or suction-cup shoes. Pushing is the easiest and simplest. It takes very little time to learn to push with a force low enough to permit hands and arms to stop the body without difficulty. The problem is to get one's center of gravity and line of thrust aligned and pointed toward the desired destination. It takes several trials to learn how to do it, but it isn't hard to do. If the line of thrust passes through the body at a point other than the c.g., one may start to tumble, but usually the rotation is slow enough to permit the tumble to be controlled and stopped when a wall or other solid object comes within reach. All of this makes it wise to have recessed handholds and padding on all sharp corners and projections.

It is possible to walk on the ceiling with shoes having a suction cup on the heel, but you really need smaller cups on the forward part of the sole as well.

"It is possible to walk on the ceiling with shoes having a suction cup on the heel, but you really need smaller cups on the forward part of the sole as well."



"Individual locomotion outside space vehicles will probably be based on use of a reaction propulsion-type unit."

Without such, when force is applied to the ankle to force the body forward in preparation for a step, the front part of the shoe pulls away from the surface and there is no force available to get the body started forward.

A much better method is to use magnetic shoes or slippers which have permanent magnets attached to the soles. Magnets with 5 lb of attraction worked but not well. It was too easy to break loose and lose all contact. Magnets with 18 lb of attraction are going to be tried next to reduce the problem of pushing away from the ceiling.

Off and on magnets

To solve the problem of being able to hold fast to the ceiling and still break loose when desired, we have designed and built a pair of electromagnetic shoes. Two flashlight batteries will power it and the circuit will be broken by lifting the heel. A potentiometer will make it possible to vary the attraction from zero to 60 lb.

Perceptive orientation during zero g

Visual orientation has proved to be no problem —

Man's antics during zero gravity

. . . continued

up stays up and down stays down, and they don't become mixed even when freely floating around the cabin. "By way of experiment," one human guinea pig reports, "I moved my arms and legs to set my body in rotation, heads over heels, with a speed of about 1–1½ rps. With a little practice I was able to make five or six turns without hitting anything in the cabin. The result was complete disorientation. Coming against a solid surface, it was impossible to distinguish what surface — ceiling, a side, or floor. Orientation was not recovered until after the pull-out started and I had spent several seconds on the floor, crushed into the mattress by the *g* forces of the pull-out."

When one walks on the ceiling with suction cups or magnetic shoes, there is an overpowering sensation that the ceiling has become the floor and that everybody else in the cabin is upside down. One sees with surprise that the pilots are flying the airplane while hanging upside down in their seats. It is quite probable that a tight safety belt to hold the buttocks firmly against a seat, coupled with the normal visual up-down associated with the instrumental panel, will suffice to provide an acceptable and comfortable up-down relationship for pilots.

Locomotion outside the vehicle

Human beings are going to have to move around outside their space vehicle — to inspect it, to transfer passengers, and to build and maintain large space stations. If the surface of the vehicle is ferrous or has magnetic particles imbedded in pathways, it would seem possible to get around with magnetic or electromagnetic shoes, not forgetting to tie oneself to the ship with a rope to prevent accidentally drifting off into space.

Individual locomotion outside space vehicles will probably be based upon the use of a reaction propulsion-type unit. Such a device can have a relatively low thrust and still be suitable because of the unique flight conditions of no air and no gravity. However, the problems are severe. Tests have proved that it takes about 17 lb of thrust to give a human reasonable acceleration, and they also demonstrated the difficulty of lining up the thrust with the body's c.g. Uncontrolled tumbling while proceeding down the cabin was the rule rather than the exception with a pusher-type, hand-held unit. So the work goes on until we can specify a rocket-type unit with appropriate controls which will satisfy human engineering requirements.

This article is based on part of the SAE-AFOSR Symposium on Astronautic Research, which is available only in book form, **Vistas in Astronautics — 1960.** To order, turn to p. 6.

Material drawn from an

SAE Metropolitan Section Paper

The IHC

Has been adapted It is designed short-haul

Based on paper by

W. E. Peterson

International Harvester Co.

A HEAVY-DUTY, high-speed, light-weight diesel engine, designed especially for trucks in the 16,000–18,000 gvw range has been added to the International Harvester line. The new engine (Fig. 1), designated D-301, develops 112.5 hp at 3000 rpm and weighs 902 lb, only 122 lb more than the V-8 gasoline engine for this type of truck. It is one of a family of four diesels adapted from gasoline engines. (See *SAE Journal*, January 1960, pp. 42–45.)

While a direct conversion from gasoline to diesel fuel in the same engine structure would be ideal from the standpoint of speed, weight, and cost of manufacture, many changes were necessary to make the adaptation. Some of the more important ones are discussed here.

Engine details

To accommodate the heavier loads imposed by diesel combustion, the wristpins are huskier, the connecting rods are longer and in heavier I-beam section. The cheeks on the crankshaft, which is made from fully hardened, C-1046 steel, are huskier, for more section modulus. The crankshaft has been lowered for longer stroke and is rifle-drilled to oil mains and connecting rods. The crankcase is a deep I-block type casting of special alloy and the main bearings have been lowered for the longer stroke. The bearing webs have been made 50% stronger for higher compression loads.

The replaceable precombustion chamber has 50% of the clearance volume. Even at the 18/1 compression ratio, the air swirl in this chamber has been found to give quiet operation, and clean burn-

D-301 Diesel

from a gasoline engine. for medium-duty, service.

D-301 Diesel Engine Specifications

Type	Valve-in-head
Number of Cylinders	6
Bore and Stroke, in.	3.812 × 4.390
Displacement, cu in.	301
Compression Ratio	18/1
Max Bhp at 3000 Rpm	112.5
Max Torque at 1600 Rpm, ft-lb	228
Piston Speed at 3000 Rpm, fpm	2150
Weight, lb	902
Valve Rotators	Positive

ing. The design permits the use of a low-pressure, open-type, injection nozzle valve.

The oil cooler and full-flow filter are bolted to the manifold — easily accessible for service. The cooler is identical with the transmission oil cooler and takes a minimum of space. The filter stops material larger than 25 microns. A schematic of the lubricating system is shown in Fig 2.

The use of special and costly starting equipment has been avoided. A 12-v glow plug is energized in each cylinder for 30–90 sec when first starting the engine. A 12-v cranking motor starts the engine easily at –25 F.

To Order Paper No. S269 . . . from which material for this article was drawn, see p. 6.

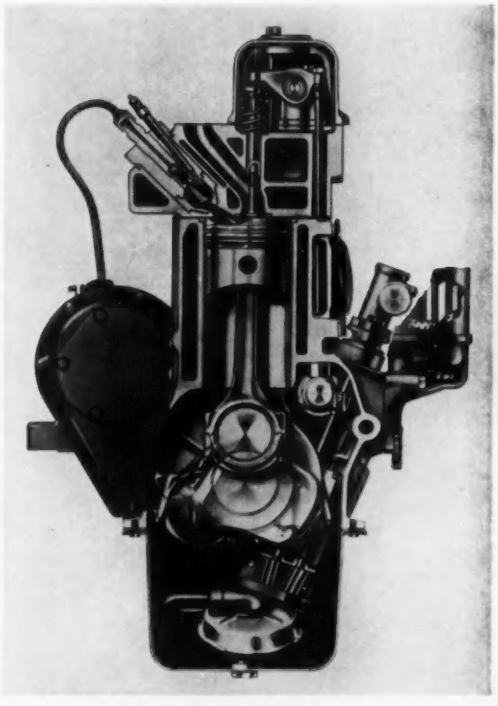


Fig. 1 — IHC D-301 light-weight diesel adapted from gasoline engine for medium-duty trucks.

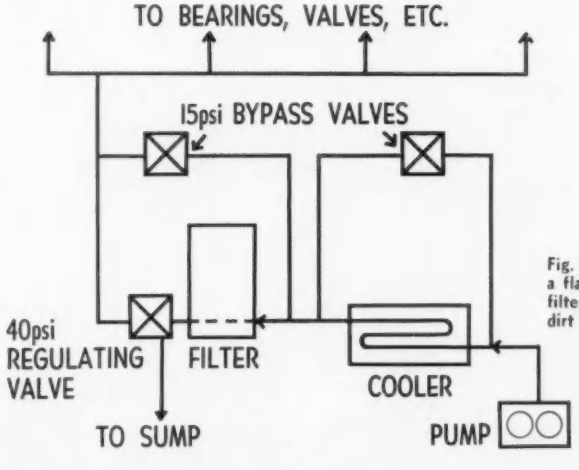


Fig. 2 — Schematic of lube system for D-301. Oil is delivered through a flat plate cooler and a full-flow filter to main gallery. Cooler and filter both have bypass valves. Pressure on clean side of filter keeps dirt from holding valve open and insures constant gallery pressure.

SAE INFORMATION REPORT
SAE
Mobile Radio Telephone for Automotive Use
TR-27
Cooperative Engineering Program
SOCIETY OF AUTOMOTIVE ENGINEERS, INC. • 485 Lexington Avenue, New York 17, N. Y.

...prospect of 4,000,000 mobile phones in '60s leads to new SAE manual

FOUR MILLION mobile radio telephones anticipated in the next decade have created the need for SAE's new Mobile Radio Telephone for Automotive Use Information Report. By developing the report now, uniform practice among manufacturers and users is expected, thus side-stepping a staggering amount of different hardware and procedures. Also, a second section of the report is intended as a guide for uniform information on manuals for individual education in the use of mobile telephone units.

Two major problems attacked in the manual are equipment envelope dimensions and recommended installation arrangements. Neither of these can be standardized at this time because of the diversity of radio equipment offered and the consequent lack of provisions for uniform installations. However, ranges in sizes, shapes, and weights are given along with typical installations reflecting good practice intended as a guide for the design of future systems. It is expected that this information will eventually "boil down" to a standardization program. This process may be speeded up by widespread introduction of transistorized equipment.

How to pick equipment

The first step toward using mobile telephones is the selection of the system best suited to an individual application. The three frequency bands are available, 25–50 mc, 150–174 mc, 450–470 mc, and have the following characteristics:

Range — For given antenna heights, the 25–50-mc band has the greatest range, the 450–470-mc band the least range, and the 150–174-mc band is between these two extremes.

Noise — The 25–50-mc band is most susceptible to interference from all types of man-made noise, such as vehicle ignition, fluorescent lighting, diathermy, induction heating, and precipitation static.

Interference — The 25–50-mc band is most susceptible to long-distance cochannel interference, particularly during periods of sun spot activity.

Costs — The initial cost and maintenance expense of the 450–470-mc equipment is generally greater than the others.

Selective calling equipment is an optional item of equipment that is thoroughly positioned for the prospective user. For fleet operation, the user can check off 15 points involved in making a decision. As outlined in the manual, these include:

- Type of operation.
- Driver safety.
- Operation in fringe areas.
- Interference reduction.
- Level of communication traffic.
- Maintenance.
- Remote signaling.
- Privacy.

The last of these general areas is, of course, an

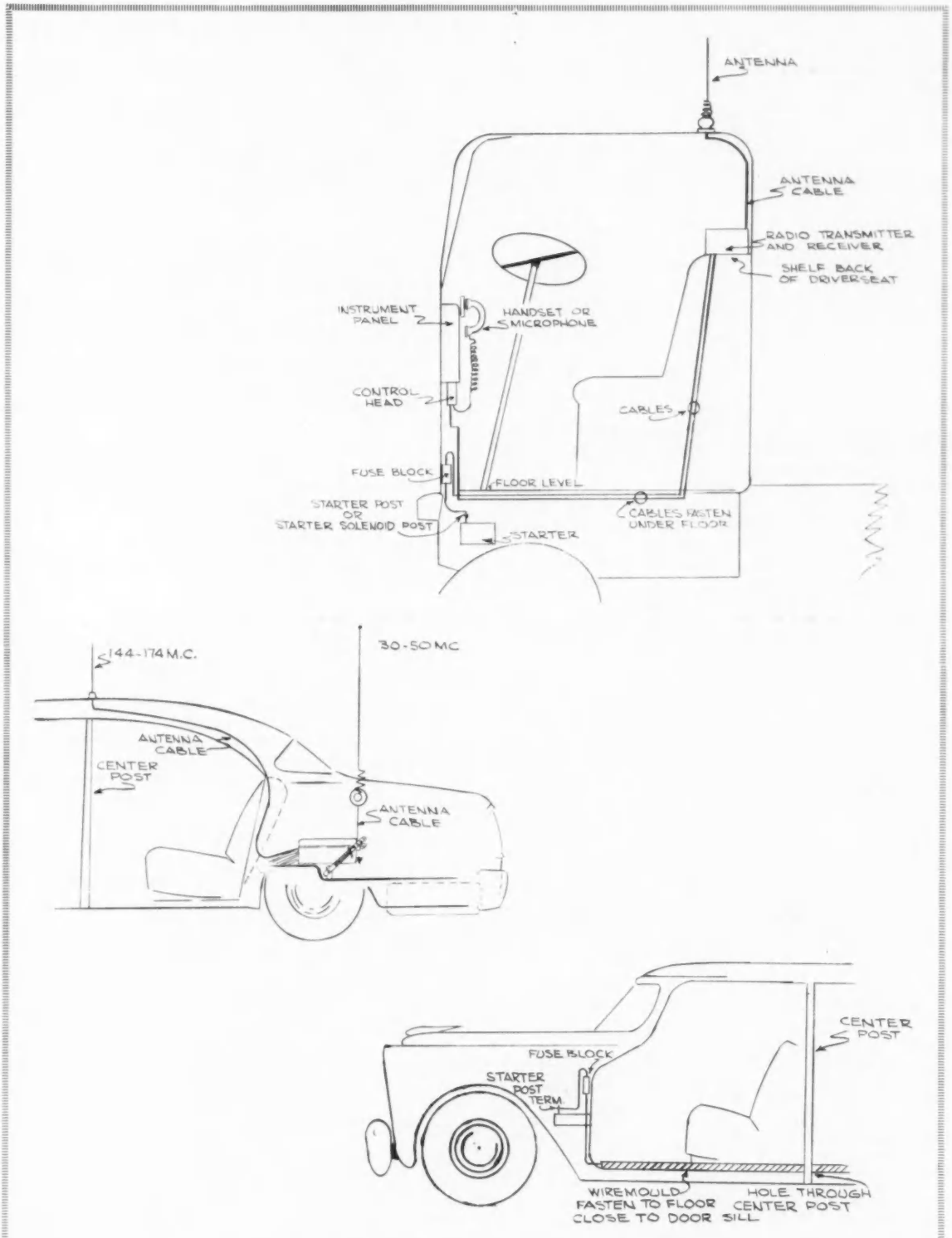


Fig. 1 — Examples of installation arrangements.

important consideration in personal mobile telephones.

To help select equipment for an existing vehicle, the manual charts the range of dimensions and weights for the basic components of a mobile radio system. These include:

1. Radio unit — This contains the receiver, transmitter, and radio power units. Sizes available range from over two cubic feet to about one quarter cubic foot. Weights can go as high as 85 lb or as low as 17 lb. A special table of weatherproof radio units is also included to accommodate commercial vehicles that don't have sufficient interior space.
2. Control unit — This houses the switches, signal lights, and other controls necessary to operate the set. Length, width, and height are tabulated, even though the volume of most units is close to 1/20 cu ft, to facilitate space planning in the dashboard area. Since space is at a premium in this part of the vehicle, exact configurations are a must.
3. Speaker unit — Typical fender-mounted speaker units are tabulated for special commercial installations.
4. Antenna — Typical sizes of antenna for the three frequency bands are outlined, along with special mounting aids that can be obtained when purchasing new vehicles.
5. Cables — Standard lengths of power and control cables supplied by manufacturers are listed to aid in component installation.

Installation and maintenance

Forty-three installation and maintenance points form a checklist for the radio system and the vehicle power supply. These are intended to help the user not only install the equipment properly, but to maintain it in good working order for long and economical life. In addition, there are pictures of typical installations and diagrams for arrangement of components and cables. Some of the latter are shown in Fig. 1.

One of the most often overlooked factors in two-way radios is the basic power supply of the vehicle. Such things as generators, regulators, batteries, and drive belts all have to be evaluated in connection with the type of equipment selected and its intended method of operation. For example, the selection of the battery size depends on two factors:

Battery size

- Length of time that the battery will be required to furnish standby power for radio operation with the engine off.
- Power rating necessary to withstand service conditions, without decreasing the life of the battery. If the battery is not used for standby service, standard equipment is satisfactory.

When standby service is necessary, the following guide can be used in the selection of battery capacity:

1. For light trucks and passenger cars with 4-hr standby, use a minimum of a 150-amp-hr battery for 6 v and a minimum of 75 amp-hr for 12 v. Both capacities are at the 20-hr rate.
2. If original equipment battery exceeds 120 amp-hr (6 v) or 60 amp-hr (12 v), then a 25% increase in capacity over original equipment is sufficient.

Users manual

Two main sections of the manual are devoted to a guide to good equipment operation by the radio station operator as well as the driver. It is expected that manufacturers and fleet superintendents will use these sections in their educational literature.

Such items as the pertinent FCC requirements, safety precautions, emergency calls, proper use of controls and equipment, and Conelrad are outlined.

The men responsible for producing the manual . . .

. . . on **MOBILE RADIO TELEPHONE FOR AUTOMOTIVE USE** are the members of the Radio Communications Suitable for Automotive Fleet Applications Subcommittee of SAE's Transportation Maintenance Technical Committee. They are:

W. C. Baylis, chairman
Niagara Mohawk Power Corp.
R. A. Beers
Radio Corp. of America
Robert Burson
Devco, Inc.
E. C. Denstaedt
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New concept in automatic landing and navigation

System would integrate airborne equipment into one package to save weight and space

Based on paper by

F. K. Preikschat

Boeing Airplane Co.

ANTICIPATING the added complexity and weight of airborne equipment which will accompany the introduction of automatic landing and blind touchdown, a new system has been conceived which integrates into one airborne package the equipment for navigation, landing, and data-and-voice communication which cannot be transmitted over the navigational and landing system.

Details of basic system

The basic system is a 3-way interrogator-transponder (Fig. 1). Interrogating pulses P_1 are transmitted over the ground transmitter 1, then are received and returned over airborne transponder 2–3. Return pulses P_2 from airborne transmitter 3 interrogate ground transponder 4–5 and are returned as pulses P_3 to airborne receiver 6. Range information R is obtained on both ends as the time difference between the transmitted and the received pulses P_1–P_2 on the ground, or as P_2–P_3 on the aircraft.

Each station (Fig. 2) transmits its own identification code — ground G and airborne A — following pulses P.

In encoder EG of the ground survey station, identification code G is attached to pulse P_1 and is transmitted over transmitter 1. When received in airborne receiver 2, pulse P_1 is passed through decoder DG only when the decoder is set to code G. Pulse P_1 is passed to encoder EA, where the identification code A of the aircraft is attached to the pulse. The return pulse, indicated as P_2 with identification A, is transmitted over airborne transmitter 3 and is received in ground receiver 4. Returns from several aircraft in the same survey area with identifications A_1, A_2 . . . A_n are received in the ground station at different times depending upon the distance of the aircraft from the station.

Received pulses P_2, with identification A, are returned from the ground station to the aircraft as pulses P_3, with the same identification A over ground transmitter 1. Therefore, only one transmitter and one receiver are necessary on each end. Received in airborne received 2, the pulses P_2 with identification A are decoded in decoder DA. Identification code A is used as address (A_1, A_2 . . . A_n) to put the related information into the data set of only that particular aircraft which had transmitted return pulse P_2 with identification code A. Received pulses

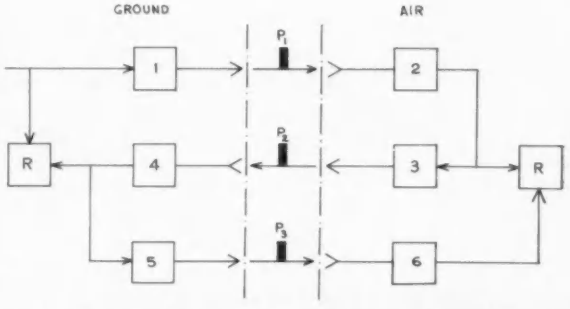


Fig. 1 — Three-way interrogator-transponder system for supplying data simultaneously to ground and aircraft. Same airborne package can be used for navigation and landing with special ground equipment.

New concept in automatic landing and navigation

. . . continued

with other identification — A_n — are rejected.

Ground decoder D receives all aircraft returns P_2 with identifications A_1, A_2 . . . A_n and puts the identification, together with the information carried by the signals, into the appropriate place of the data storage, designated as A_1, A_2 . . . A_n. The additional data and communication link transmits data that cannot be sent over the basic system, such as barometric altitude course and speed of the aircraft, data about altitude course and speed to be flown, and voice communication.

Navigational system

The interrogators of the ground survey stations G (Fig. 3) are equipped with directional scanning antennas. The rotation of the antennas of all ground stations is synchronized with time; thus, the antennas point in the same direction at the same time, and toward the north at the full hour and every 10 sec thereafter.

The distance of the aircraft from the ground station is obtained as described under the basic system. In the ground station the bearing angle is obtained with the usual radar technique.

In the aircraft, the bearing angle is obtained from the time required by the scanning ground antenna to run from north to the direction of the aircraft. A clock in the aircraft measures the time from every full 10 sec of the hour to the moment at which the main lobe from the scanning antenna on the ground is received. The bearing angle is proportional to this time interval.

Trunk routes are equipped with ground stations $G_1, G_2 \ldots G_n$ with overlapping ranges. Aircraft traveling on trunk routes have to change code G to continue operation with the ground stations when they pass from one survey area to another. To enable the ground station to obtain identification from the aircraft when the pilot does not set the proper code G_n, the ground stations and the aircraft may be equipped with one common code, G_o, which does not depend on the pilot's choice.

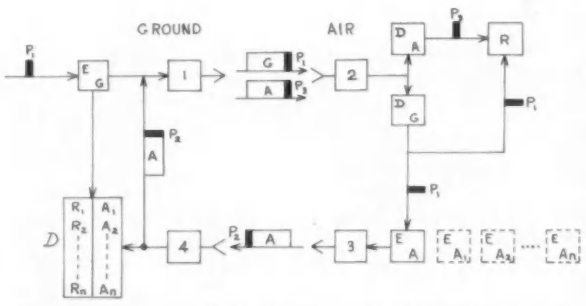


Fig. 2 — Basic system with identification codes. Each station transmits own code (ground G, airborne A) that follows pulses P.

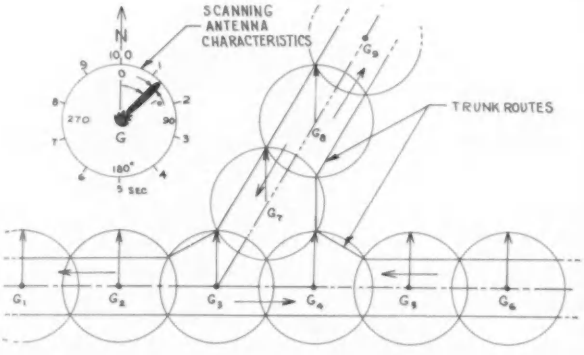


Fig. 3 — Ground survey stations of the navigational system. Interrogators are equipped with scanning antennas.

Landing system

The range in the landing system is obtained as described in the basic system. The vertical and lateral angle are measured by a receiving antenna system near the touchdown point of the runway. The angles are used in the control tower to indicate the location of the aircraft on the approach. They are encoded and transmitted to the aircraft attached to return pulse P_2, with identifications A_1, A_2 . . . A_n as addresses. As an alternative, the lateral angle can be obtained by a localizer antenna like that on ILS.

The approach path to a runway is the extended runway centerline. The lateral guidance system must indicate this centerline with zero reading signals and off locations with error signals that do not necessarily indicate true angles.

For the glide-slope angle, however, true angular indication is necessary so that the approaching aircraft, depending upon only its performance, may have free choice of the glide-slope angle. The pilot dials the wanted glide-slope angle in the airborne set, and error signals are then derived from the preset angle by an airborne computer.

A monopulse technique is used in the ground station to measure the approach angle. Measurement and encoding of the angular information must be performed within the time during which return pulse P_2, with address A, is transmitted back to the aircraft. The angular information is transmitted as a code sequence, with a small spacing behind the address. The entire process is completed within the time that is available between the reception of return pulses P_2 from two aircraft, the second of which is located behind the first one on the approach at the shortest distance that is required for the highest landing rate.

To order Paper No. 237C . . .
from which material for this article was drawn, see p. 6.

Valve failures are

designed-in . . .

built-in . . .

or driven-in.

The **designing-in** of certain thermal or mechanical patterns adverse to valve life happens to even the best of engines. Satisfactory parts can be **built-in** during assembly or overhaul in a manner to predispose them to failure.

Finally, even with the best in design and the best in assembly technique, an engine can be flogged to death in service — the failures are **driven-in.**

Many variables interact to produce valve failures and these variables can combine in an almost infinite number of ways.

Basically, however, there are two major kinds of valve failures — burning and breakage. And the two major variables contributing to these failures are mechanical and thermal.

Starting with these basic factors it is possible to construct a flow chart that imposes a sense of order on the subject. Such a chart is shown on accompanying pages, and if it is read from the bottom up, causes of failure can be traced with a minimum of confusion.

On the following pages, some of the failures noted on the chart are illustrated and accompanied by comments on their cause and cure.

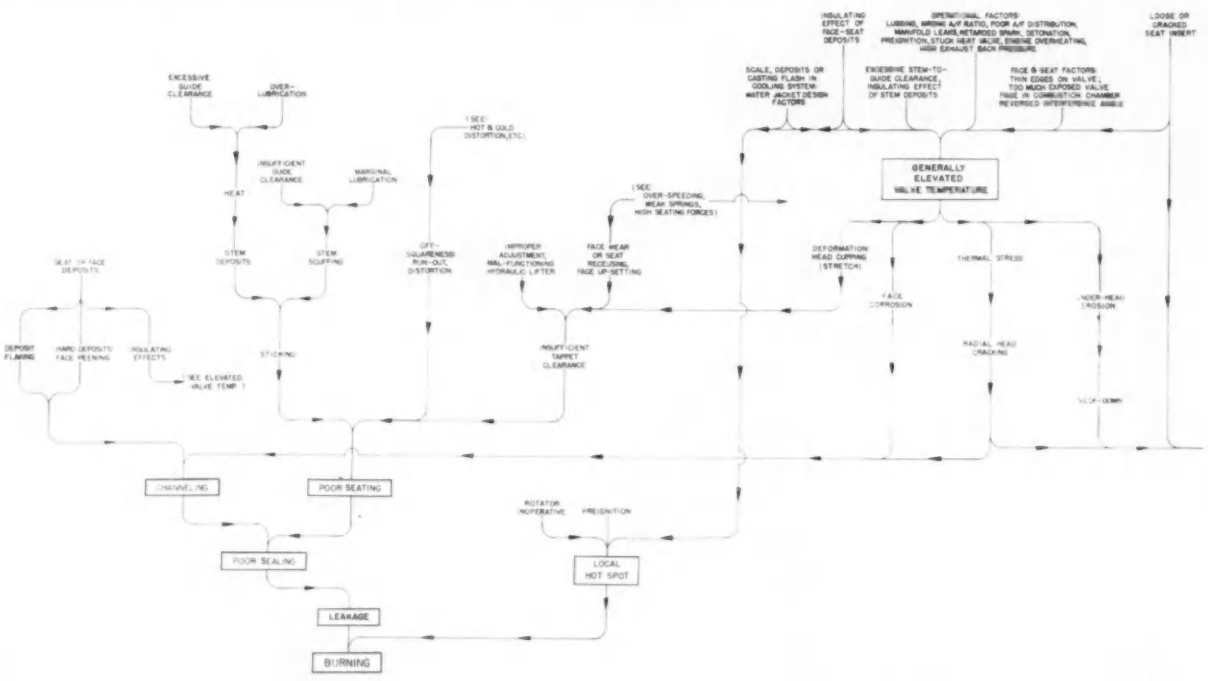
Why Valves Fail

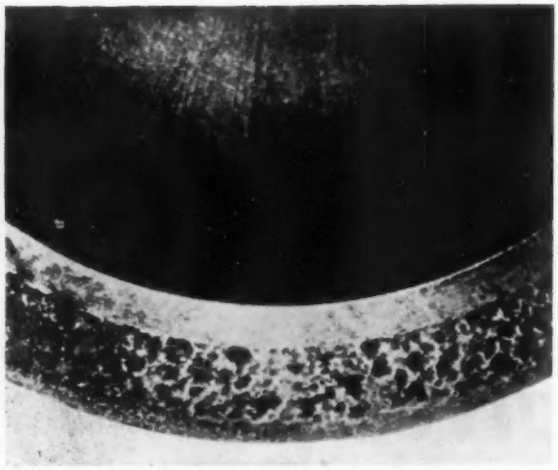
Based on paper by

A. K. Hannum

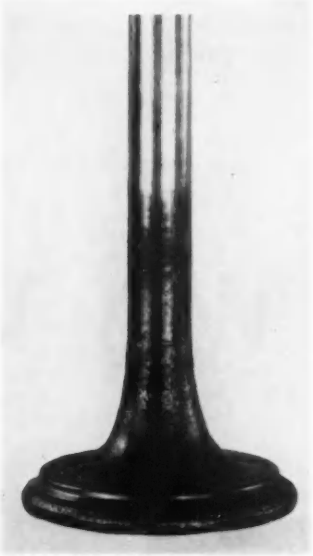
Thompson Products Replacement Division, Thompson Ramo Wooldridge, Inc.

Factors leading to valve failure

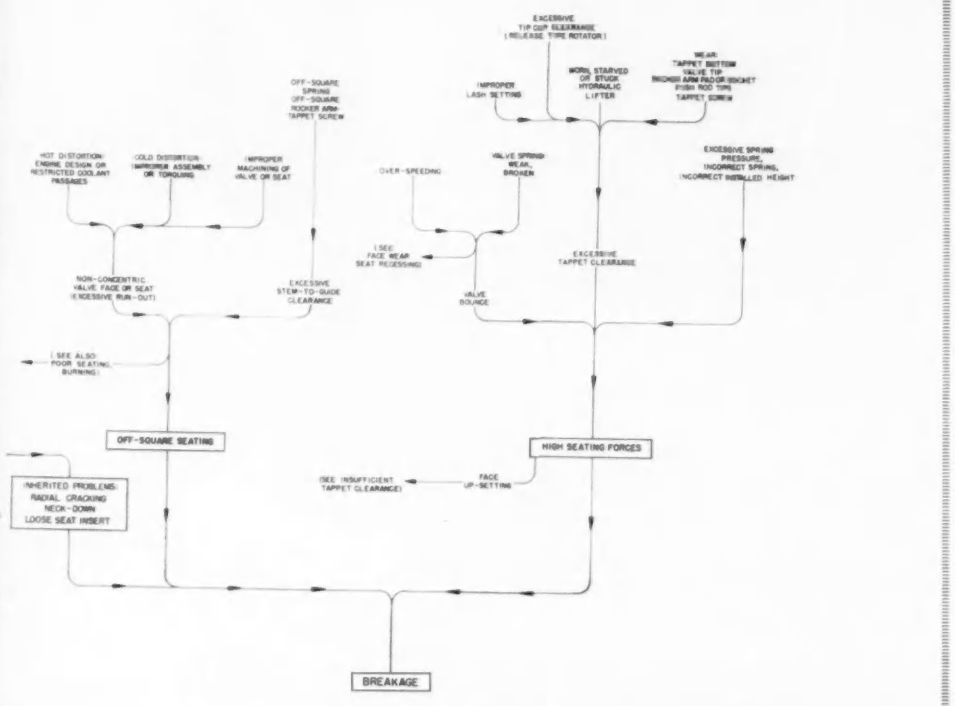


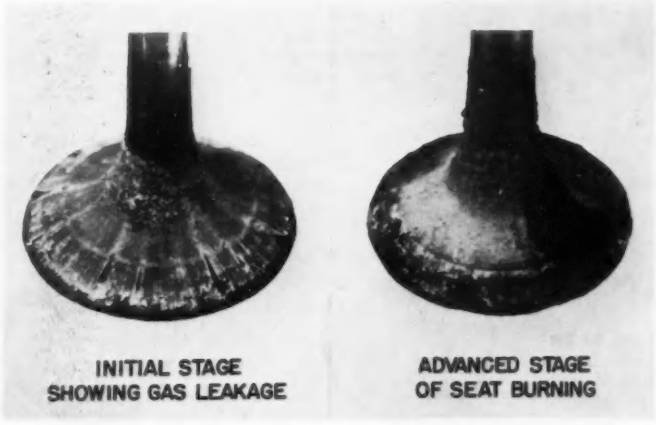


CHANNELING and leakage past the valve face can be caused by extensive peening when hard combustion deposits or foreign material lodges between valve face and seat. Deposits on a valve face have an insulating effect, which tends to raise operating temperatures and generate the troubles shown in the center portion of the chart. Hard-facing materials help to resist peening, and rotation will keep face deposits at a minimum.



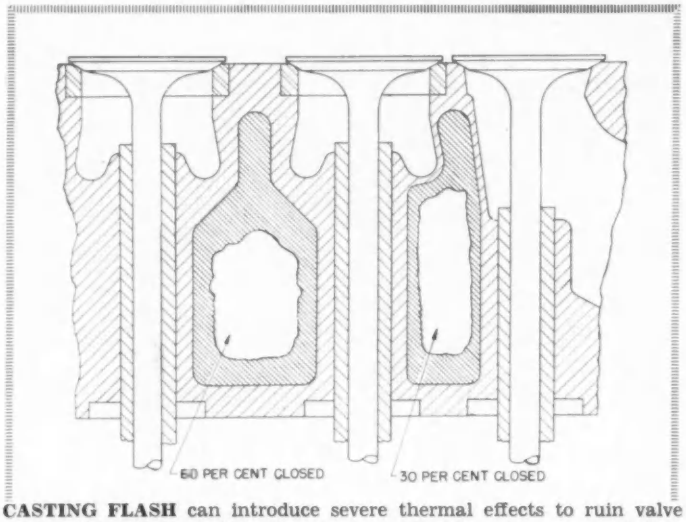
VALVE FACE WEAR, as well as seat recessing, can result from sustained high engine speeds, coupled with weak, broken, or badly installed valve springs. Self-rotation causes excessive grinding between valve face and seat, and one or the other will wear at a high rate depending upon the materials used. Rotators can cause this type of wear if valve and seat material, or seat material, is not proper and the fuel is unleaded, or dry such as LPG.


EXCESSIVE TIP CUP CLEARANCE (RELEASE TYPE ROTATOR)
WORN, STARVED OR STUCK HYDRAULIC LIFTER
IMPROPER LASH SETTING
OFF-SQUARE SPRING OFF-SQUARE ROCKER ARM-TAPPET SCREW
HOT DISTORTION: ENGINE DESIGN OR RESTRICTED COOLANT PASSAGES
COLD DISTORTION: IMPROPER ASSEMBLY OR TORQUING
IMPROPER MACHINING OF VALVE OR SEAT
OVER-SPEEDING
VALVE SPRING WEAR, BROKEN
EXCESSIVE SPRING PRESSURE, INCORRECT SPRING, INCORRECT INSTALLED HEIGHT
(SEE FACE WEAR SEAT RECESSING)
EXCESSIVE TAPPET CLEARANCE
NON-CONCENTRIC VALVE FACE OR SEAT (EXCESSIVE RUN-OUT)
EXCESSIVE STEM-TO-GUIDE CLEARANCE
VALVE BOUNCE
(SEE ALSO: POOR SEATING, BURNING)
OFF-SQUARE SEATING
HIGH SEATING FORCES
(SEE INSUFFICIENT TAPPET CLEARANCE)
FACE UP-SETTING
INHERITED PROBLEMS: RADIAL CRACKING NECK-DOWN LOOSE SEAT INSERT
BREAKAGE



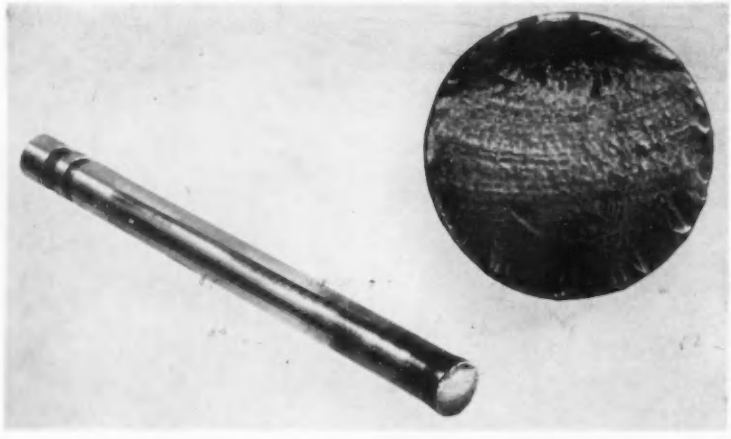
POOR SEATING caused by insufficient lash or sticking is shown at left. The blowby marks could be buffed off and little damage would be evident. A few more hours of high-output operation and the valve will be beyond repair, as shown at right. Gradual accumulation of valve stem deposits can make seating less and less positive and lead to the conditions shown.

Why Valves Fail . . . continued



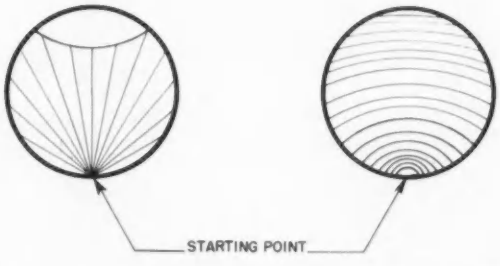
CASTING FLASH can introduce severe thermal effects to ruin valve jobs. When thermal distortion occurs with adequate water-jacketing around the valve ports, look for some obstruction to the passage of the coolant. Remove grease, scale, and mineral deposits from cooling system when overhauling. In case of a local distortion problem, investigate individual passages around and between valve ports with a wire or probe.

IMPACT FAILURE of valve head caused by high seating forces. Initial failure was probably transverse. When the engine is not shut down promptly, the head may be broken away until only a nub remains. Causes of high seating forces are shown in the upper right of the chart.

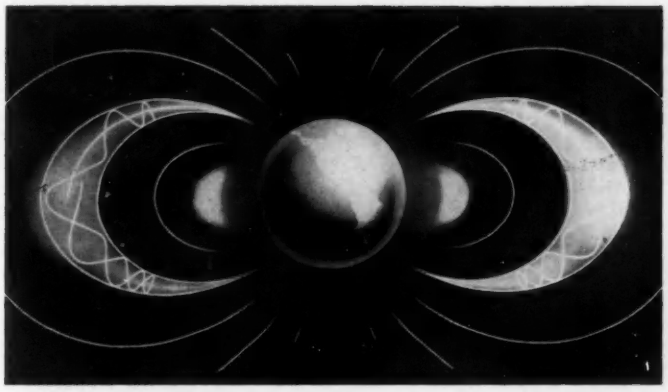


STEM FATIGUE FAILURE, caused by repeated flexing due to misalignment, normally occurs between the underhead and point where the valve stem enters the guide. The magnified cross-section of the progresive, crescent-shaped lines across the part from the initial point to the final arc of breakage shows the creeping nature of such a failure.

VALVE STEM FAILURE can also be caused by impact. It will often occur adjacent to a change in cross-section, such as a stem relief or lock groove. Here impact and fatigue failures are contrasted.



To Order Paper No. 249A . . .
from which material for this article was drawn, see p. 6



Radiation

—major factor in space travel

. . . affects size, weight, design, and trajectories of spacecraft

Based on paper by

Homer E. Newell and John E. Naugle

National Aeronautics and Space Administration

SINCE the discovery of the Van Allen radiation belts and the phenomenon of the so-called solar proton beam, or solar cosmic rays, radiation has become a major factor in space travel. And the effect of radiation on various space missions, such as Project Mercury (to put a man in orbit around the earth), circumlunar flights, and the operation of unmanned satellites and space probes, has required assessment.

Implications for Project Mercury

Project Mercury will be unaffected by the three possible hazards — cosmic radiation, solar cosmic radiation, and trapped radiation. The dosage from cosmic rays is reduced to 0.7 R/year by the shielding effect of the earth's magnetic field, which is well within prescribed tolerance. The slow, heavy nuclei have also been removed by the magnetic field. The actual number of particles striking an astronaut will be less than 5% of what struck Col. D. G. Simons during his record-breaking flight to 101,516 ft in a balloon. The desired orbit of Mercury lies below the inner belt, therefore, there is no danger from trapped radiation. The frequency of solar proton events will be down as the current solar activity declines. Moreover, the magnetic field confines the protons from these events to the polar regions.

The trapped radiation and the solar cosmic rays are a hazard to missions where trajectories exceed an altitude of 500 km or extend more than 60 deg north or south of the magnetic equator.

Inside the radiation belt

The radiation level inside the inner radiation belt exceeds 20 R/hr. The energy spectrum is flat, therefore a large amount of shielding is needed to protect a man in this region. It would take 45,000 lb of shielding to reduce the radiation level to 0.5 R/hr inside a compartment 4 ft in radius. A man would receive his allowable yearly dose in 10 hr, even with this amount of shielding. This would seem clearly to preclude manned observatories in this region.

The radiation level in the outer belt is high because of the Bremstrahlung produced by the electrons stopping in the outer shell of the spacecraft. The dose rate is about 1 R/hr behind a 60 g/cm^2 carbon shield, owing to the electrons in the outer belt. Adding an inner layer of 0.25 cm of lead will reduce this dosage by a factor of 10. These figures are for the maximum in the outer belt and at a time of maximum intensity. So we see again that it is impossible to have manned vehicles in this region for extended periods of time.

Outside the radiation belts

The normal dosage in the region outside the radiation belts will be the cosmic ray background level of about 5–10 R/year. However, the solar cosmic rays — the solar proton beams — make the shielding problem complex. Outbursts of solar cosmic rays occur at random and we cannot as yet predict them with certainty, though observations of solar activity do make it possible to state the high or low probability of an event within 4 or 5 days of observation. K. Anderson has worked up a promising method of prediction, based on the size of the penumbra of sunspots. Checks against past events are very encouraging.

The magnitude of the exposure varies from event to event and cannot be predicted as yet; our knowledge of the phenomenon is limited by the newness of the discovery. And the amount of added data which can be obtained is limited to the next year. After that, there will be almost no opportunities to obtain more data until 1967 when plans and vehicle

construction for the circumlunar mission will be well underway. Shielding concepts for this mission, therefore, must be solved on the basis of available data.

There are a number of factors to be considered: Should the vehicle carry sufficient shielding to keep the radiation level in the spacecraft below 0.300 R/quarter (maximum dosage for radiation workers) for the largest flux observed to date? This would require an immense amount of shielding and might, by displacing redundant control systems that would otherwise be provided, subject the crew to more hazards of a different nature. Perhaps the shielding should be sufficient only to protect the man during passage through the radiation belts, and the solar proton events should be regarded as an emergency. A small shielded "storm cellar" would be shielded sufficiently to reduce the radiation level to where the man would receive no more than the 25-R emergency dose. Interplanetary flights would then be scheduled when the probability of a solar flare was small, just as airline flights are routed around tornados.

Effect of radiation on materials

Generally speaking, radiation dosages of 10^5–10^6R are required to damage electronic components and these dosages do not come from trapped radiation or solar cosmic rays. However, an integrated flux of 10^{13}–10^{15} 1.7 Mev electrons or 10^{10} 18 Mev protons on a square centimeter of solar cell will reduce the output to 75% of its initial value. Electrons of energy greater than 0.15 Mev and protons of greater than 0.2 Mev can damage solar cells. Continuous exposure of bare solar cells in the center of the inner Van Allen belt could limit their life to a period ranging from 6 hours to 5 weeks, depending upon the proton flux which is assumed in the as yet unmeasured energy region below 40 Mev. The glass-covered solar cells in Vanguard I are still operating after 2 years of exposure to the inner belt. The full extent of damage may not be indicated in this case because Vanguard I requires only a low current drain. And in any event this is not a satisfactory solution to the problem. Such a shield adds greatly to the weight of a solar power supply. Moreover, recent measurements by Denny[1] have shown that 10^{10}/cm^2 protons of 350–750 Mev will also lower the efficiency of solar cells by 25%. Against such particles, glass shields of reasonable thickness would be ineffective.

[1] "Radiation Damage in Satellite Solar Cell Power Systems," J. M. Denny. ARS Report No. 1295–60.

Need for research

Research and development are required to produce long-lived solar power supplies for use on satellites which must operate for long periods within the inner radiation belt. On the observational side, further measurements must be made in the 0.5–10 Mev region of the proton spectrum in the Van Allen belts to determine the exact shielding required.

This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.

Quieting jet noise boosts costs

Based on paper by

W. R. Walley and R. N. Gardner

Douglas Aircraft Co., Inc.

IF the price that will be paid for quieting jet airplanes could have been put into one package, it seems that the industries and airlines could have well afforded to purchase the real estate and homes in the vicinity of airports and come out ahead financially.

This conjecture stems from recent studies evaluating the cost of the jet noise abatement program. It is based on a conservative estimate of the cost to the airline industry in a 10-year period, totaling better than 370 million dollars for an assumed jet fleet of 400 planes. The cost per plane, in this period would be about 17% of the purchase price. It is felt that the actual costs will be substantially greater than these figures since the costs that were not evaluated would be a large percentage of those which were.

Costs increased by drop in range

The major source of increased costs, evaluated by a recent Douglas study, is the deterioration of the aircraft performance capabilities attributable to the addition of the sound suppressor.

The losses in cruise depend upon the cruise power available and the type of cruising operation. Typical long-range and high-speed cruising data for two different engine installations, the JT3C-6 and JT4A-3, illustrate this.

In long-range cruise at 99% of maximum specific range (99% max mile/lb), both the speed and the fuel flow change. The speed losses are primarily due to the drag increases associated with the supressor-reverser installation. Loss of speed means reduced range for a given fuel flow. The loss of thrust, due to inefficiencies introduced by the reverser-suppressor, affects fuel flow and thus also reduces specific

range. The per cent change in fuel flow for a given per cent change in thrust setting is greater at high thrust settings than for more moderate settings. Therefore, at the same weight and altitude, the effect on range losses, due to thrust loss, would be greater for the lower rated JT3-6 version. Actually, the loss in range performance at representative cruising altitudes is approximately 5.5% for both installations.

One type of high-speed cruise operation is simply to fly at maximum cruise thrust. This is a practical operation for the relatively thrust-limited aircraft such as the DC-8 with JT3C-6 engines. In this case speed losses due to the suppressor reverser assembly range from 1.5 to 8% and cause range losses of some 1.4% at light weights and about 6% at heavy weights.

Practical high-speed operation of the JT4A-3 version is essentially a constant Mach number cruise at the drag divergence Mach number. Only fuel flow matters in this type of operation, and the full effect of the thrust loss and drag increase is reflected in the specific range. For example, at a constant 0.83 Mach number the percentage loss in nautical miles per 1000 lb of fuel is almost constant at 6%.

These losses in cruise performance result principally from the provisions for noise suppression. However, the suppression and reversing devices of the production nozzle are so integrated that it is virtually impossible to assign cruise losses to their separate functions. It has been estimated, however, that if a reverser were designed for a simple conical nozzle, the losses would mount to 0.5% in cruise. These would be mainly due to leakage drag. The remaining losses are then ascribed to the suppressor.

Operating costs

To compare the costs for different types of operation, some method of bookkeeping must be adopted. One generally accepted basis for comparing operating costs is the direct operating cost computed by the ATA equations. In making the computations for this study three range operations were assumed: a medium-range JT4A-3 flight with full payload, a medium-range JT3C-6 flight of the same type, and a long-range JT4A-3 flight in which payload was sacrificed for fuel carried. This last is an example of a critical route segment.

For the noncritical JT4A-3 flight a range of 2200 nautical miles was used, flown at 0.83 Mach. The resulting airplane-mile costs are 1.87 $/n.mile using the plain nozzle and 1.95 $/n.mile using the production nozzle, an increase of 4.3% due to the supressor-reverser installation. For the 200-lb revenue unit, approximating a passenger with baggage at 100% load factor, the respective costs for the 116-passenger DC-8 are 1.13 ¢/200 lb n.mile and 1.18 ¢/200 lb n.mile.

For the JT3C-6 case a flight of 2000 nautical miles at maximum cruise thrust was assumed. The effect here was to increase the direct operating cost by 4.5%, assuming no payload reduction.

The penalty for these flights is not so great as to have a crippling effect on the profit margin. On critical routes, though, the penalty paid for the suppressor-reverse is a sizable one. To typify such a route a JT4A-3 over-water flight of 4122 nautical miles at long range cruise was chosen. This operation was set up so that the airplane was just able to carry full payload with the plain nozzle case. This is representative of a range problem utilizing the maximum structural take-off weight of the airplane without any regard to a possible runway length limitation.

The increase of airplane-mile costs, as expected, was essentially the same as before, 4%. The factor which caused the crushing cost increase in this case was the 10,500 lb reduction in payload which had to be replaced by fuel, when the production nozzle is used. As a result of this, the revenue unit costs for this 132-passenger airplane jumps from 1.23 ¢/200 lb n.mile with the plain nozzle to 1.81 ¢/200 lb, n. mile with the production nozzle, an increase of 47%. Fortunately, this reduction in payload can be accomplished by off loading air freight before passengers and baggage, the revenue from this source being approximately one-third to one-half that of the equivalent weight of a passenger and his baggage.

When limited take-off runway length causes an additional reduction in payload, even greater increases in operating cost results. For the JT4A-3 version, there is approximately a 1% gross weight loss due to the suppressor-reverser, with a limited length runway. At high gross weights, this amounts to some 3000 lb. Combining this with the critical case yields a 58% increase in ¢/200 lb n. mile for the production nozzle over the plain nozzle.

The cost differentials in terms of the total direct operating cost in $/hr for each of the cases examined are, in order of presentation, 36.75, 24.40, and 31.65 $/hr. Taking the mean of these and assuming a 300-hr annual utilization, the annual cost penalty per airplane is $93,000 based on the ATA cost method. While these costs were computed for the DC-8, all of the current suppressor-reverser configurations have overall losses of the same order. It is on this basis that the 10-year projected industry cost of 370 million dollars was computed.

This estimate does not include any loss in revenue when the payload is restricted for any of the reasons outlined. It also neglects all sorts of extraneous costs and costs not properly accounted for by the ATA formulas. Most of these costs are related to the noise problem and have nothing to do with reversers.

Important additional losses due to jet noise, which must be borne by the airlines, arise from gross weight restrictions caused by selective runway usage and noise abatement flight paths enforced at many terminals. Thus, any 10,000-lb payload reduction from the maximum would increase the direct operating costs by some 38–40%. The cost of circuitous or inefficient climb operation can perhaps be appreciated when it is realized that, in terms of direct operating cost, each wasted minute at full power costs upwards of $20.00.

Substantial costs are also being encountered from such changes as the shifting of training flights to relatively isolated fields, thereby adding landing fee and ground support expenses. Even the expenses of lengthening runways, charged to the airlines, has been laid in large measure to the sound suppression program.

To Order Paper No. 238C . . .
from which material for this article was drawn, see p. 6.

Here's how the first U.S. astronaut will survive in

THE MERCURY SPACE VEHICLE, soon to be test-launched, is expected to carry an astronaut into an earth-circling orbit. Although the first efforts to loft the capsule into space will not involve manning the vehicle, the environmental control equipment in it will eventually support human life in hostile space.

Based on paper by

Edward H. Olling
AiResearch Mfg. Co.
and
J. R. Barton
McDonnell Aircraft Corp.

THE first U. S. man in space, housed in the Mercury capsule, will survive with the aid of a carefully engineered life support system. Proved components will keep him supplied with oxygen, while the temperature, pressure, and odor, CO_2, and moisture content of his surroundings, are closely controlled.

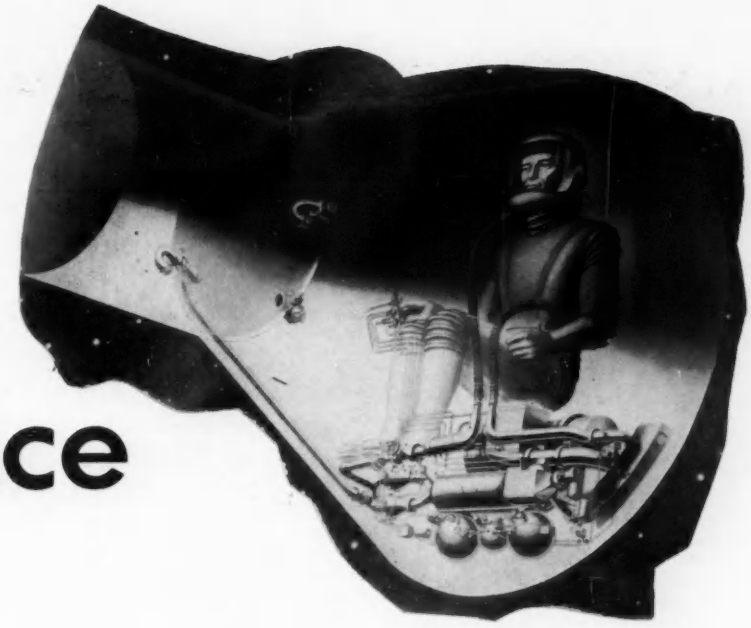
The heart of the control system, which will regulate the astronaut's environment, is the oxygen supply system. Four pounds of oxygen will supply all breathing, pressurization, and leakage requirements for 28 hr of orbital operation. This source will also be used for 2 hr of prelaunch operation and launching period, and for ventilation during the 12-hr post-landing phase.

High reliability of the oxygen supply system is assured by redundancy of pneumatic components, where two components are used in parallel, either of which can accomplish the desired control objective. In keeping with this philosophy, two oxygen circuits are employed in the capsule. The occupant is supplied directly from a closed-loop pressure suit circuit, while the cabin is pressurized with oxygen and provides a cushion of safety should the suit circuit fail. These two circuits are represented schematically in Fig. 1.

The environment of the astronaut will be controlled in the following manner. When the vehicle rises above a pressure altitude of 27,000 ft the cabin is maintained at a pressure of 5.1 psia, by receiving oxygen to make up for leakage losses. This low pressure, considered to be suitable for sustaining life, is favorable from the standpoint of structural weight minimization and leakage rate reduction. If cabin pressure drops below 4 psia, oxygen flow to the cabin is halted to prevent wasting the supply when higher pressures cannot be maintained.

The suit is kept at 3 in. of water less than cabin pressure and the suit circuit pressure is limited from between 2 to 9 in. of water above the cabin pressure during normal operation. However, when the cabin pressure is less than 4.6 psi, then the suit circuit pressure is maintained at this limiting value.

The suit circuit is protected by a pressure relief



space

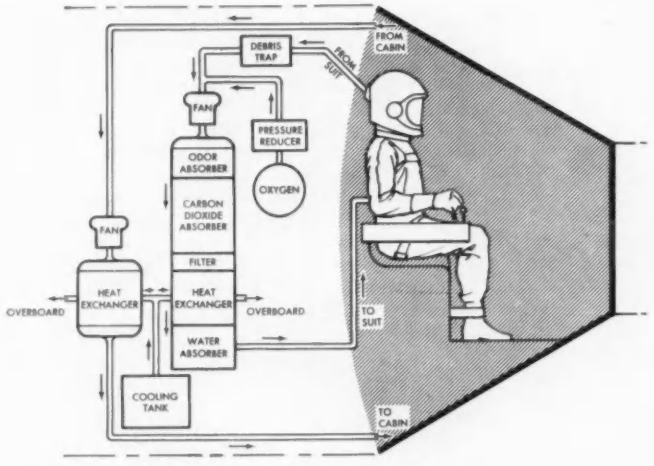


Fig. 1 — Two oxygen circuits of the Mercury space capsule are shown here. The atmosphere of the suit is constantly recirculated for cooling, cleansing, and recharging with oxygen. Some of the gas is allowed to enter the cabin to make up for leakage losses.

valve which will not allow the pressure differential from suit to cabin exceed 5.0 psig. The capacity of this unit is designed to meet all anticipated flow rates.

Another safety feature is the emergency O_2 rate valve, which operates automatically when the suit pressure drops below 4.0 psia to provide an emergency flow of oxygen. This results in a very tight short loop from the oxygen supply system, through the suit and into the capsule. Means are also provided to allow the pilot, at his own discretion, to select emergency oxygen rate flow.

During the return phase of the mission, when the vehicle descends to a pressure altitude of 27,000 ft, a cabin pressure relief valve starts to open to allow the cabin pressure to be increased to ambient pressure. When the 20,000-ft pressure altitude level is reached the ground inflow and outflow ventilation valves will open to ventilate the suit circuit. In addition, the emergency oxygen rate valve opens automatically to supplement the air being drawn into the suit circuit for pilot breathing and cooling.

To make the environmental control system as reliable as possible, all automatic functions have a manual backup. In addition, only forced methods of fluid flow are used, avoiding reliance on natural effects to produce such movement.

Oxygen supply equipment

As the pilot consumes oxygen, and as leakage from the capsule occurs, replacement of the oxygen from the oxygen supply takes place.

This supply is composed of a normal and an emer-

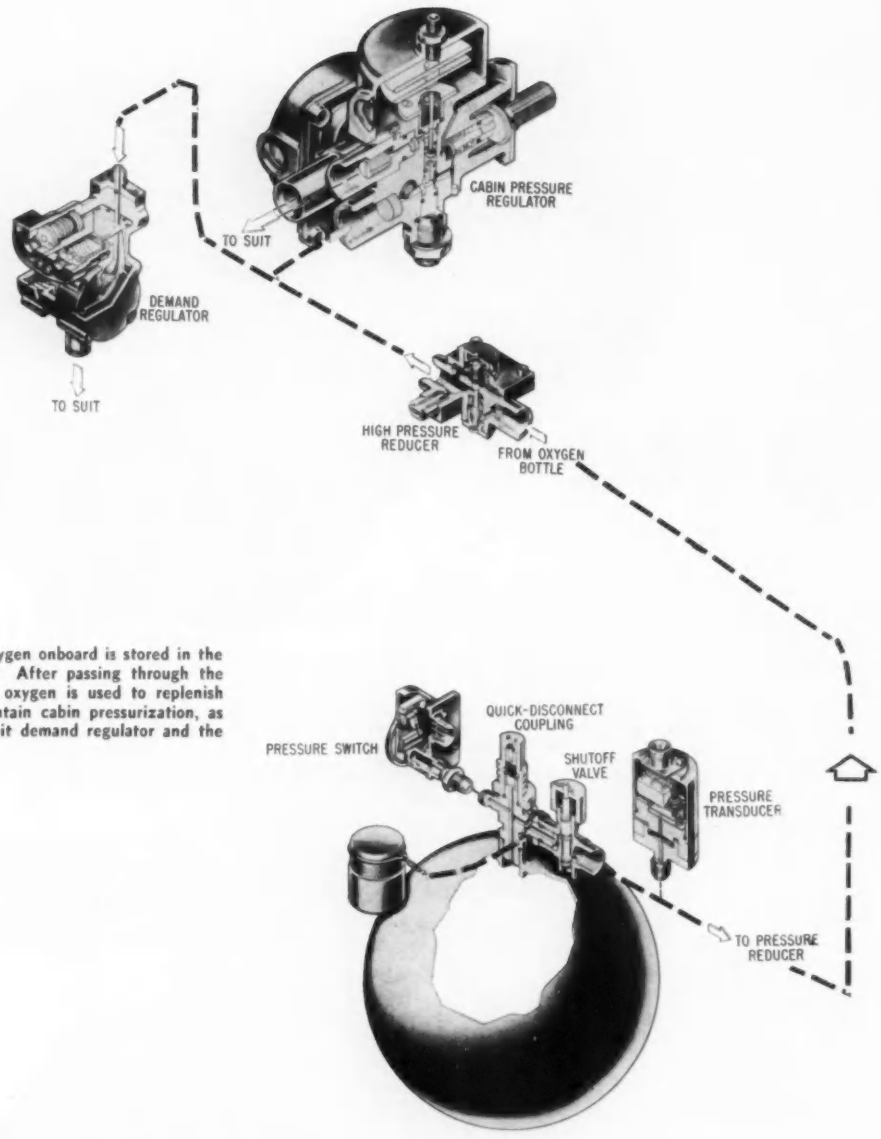


Fig. 2 — Four pounds of oxygen onboard is stored in the gaseous state at 7500 psi. After passing through the high-pressure reducer, the oxygen is used to replenish the pilot's supply and maintain cabin pressurization, as called for by the suit circuit demand regulator and the cabin pressure regulator.

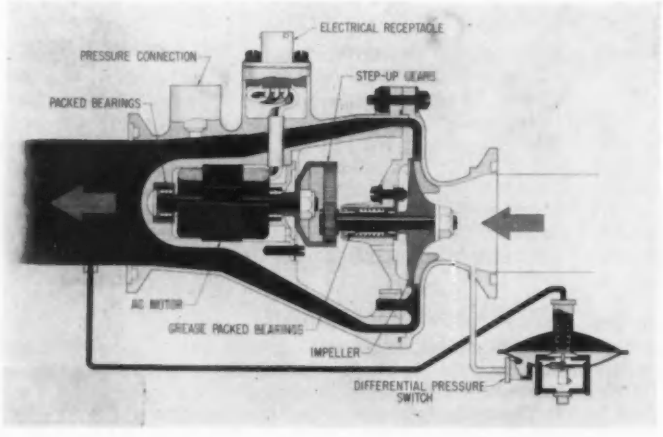


Fig. 3 — Suit circuit compressor is a rugged machine capable of withstanding 100 G's. To eliminate the hazard of contaminating the oxygen supply with lubricant, the bearings are packed with grease.

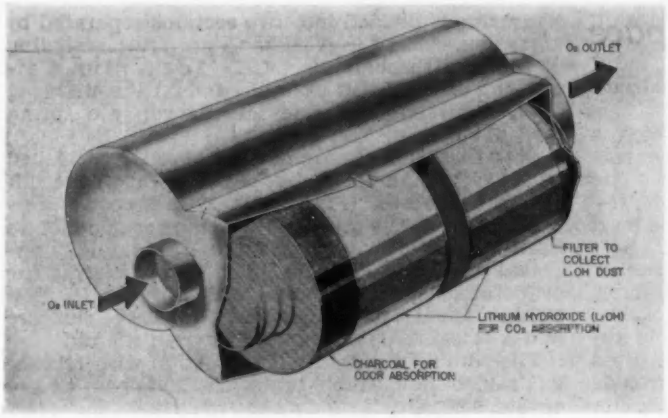


Fig. 4 — Odor and CO_2 absorber employs charcoal and lithium hydroxide as the active agents. A filter is provided at the outlet side of the unit to collect the LiOH dust which might otherwise harass the pilot. The contents of the cannister will last for about 31 hr.

survival in space

. . . continued

gency oxygen bottle. These spherical, electrolessly plated steel containers store the oxygen at 7500 psig at 70 F. The oxygen is kept in the gaseous state, ensuring a homogeneous supply under all weightless and gravity situations. In conjunction with the bottles, quick-filling disconnects, oxygen shutoff valves, oxygen pressure transducers and pressure switches are provided. The oxygen supply and distribution system is illustrated in Fig. 2.

The pressure of the oxygen admitted into the system is lowered by the two single-stage, high-pressure, reducing valves operating in parallel. Either one of these valves can handle the entire flow to the suit and cabin circuits; the suit circuit flow being regulated by the demand regulator, and the cabin flow by the cabin pressure control valve.

It is the primary function of the suit demand regulator to maintain the prescribed suit and suit circuit pressures relative to cabin pressure. In addition to this, it has provisions for relieving suit circuit pressure during ascent and to prevent overpressurization of the suit circuit during descent.

Should a malfunction occur in the regulator or in the suit circuit recirculation system, causing the pressure to drop below 4 psia, the emergency oxygen rate valve is aneroid actuated to supply an increased oxygen flow to the pilot for cooling, breathing, and pressurization. This action also causes a system shutoff valve to close and the the suit circuit compressor to stop. The system emergency shutoff valve, along with an O_2 check valve at the water absorber outlet, acts to isolate the pressure suit from the remainder of the circuit when the emergency O_2 rate valve is passing oxygen. When the normal 5.1 psia pressure level of the suit is re-established, the aneroid is retracted and the emergency rate and emergency shutoff valves may be reset.

A manual mode of operation permits the astronaut to select emergency rate flow at his discretion, and also to shut it off.

The cabin pressure control valve is the device that maintains cabin pressure at 5.1 psia above pressure altitudes of 27,000 ft. This valve feeds its ogygen first into the suit circuit, for use there, and then these gases flow through the suit circuit relief valve into the cabin. To avoid oxygen loss the control valve will automatically close when cabin pressure drops excessively. Again, two control valves are used, in one housing.

In case of fire, a lever on the cabin pressure relief valve may be manually actuated to decompress the cabin and thus extinguish the fire. Repressurization provisions exist, which allow the pilot to re-establish cabin pressure after decompression.

Suit circuit

The suit circuit forms a closed loop in which the artificial life supporting atmosphere is maintained and recirculated.

The suit atmosphere first passes through a debris trap where any nauseous material, hair, lint or nasal secretions are removed by a filtering element. This solids trap consists of a cylindrical micron mesh screen filter, mounted within the duct from the pilot's suit. In case of clogging, a bypass relief valve will prevent blockage of the system loop.

After the addition of fresh oxygen from the bottle, the atmosphere flows through the normal suit circuit compressor. This unit is a single-stage, centrifugal compressor, driven by an electric motor through a stepup gear train. In the event of compressor failure, a differential pressure switch would sense the deterioration of the compressor pressure rise if it drops below 3.5 psi. The switch then shuts down the normal compressor and starts the standby compressor, which is a duplicate unit. The compressor and switch are shown in Fig. 3.

Both of these compressors are designed to operate after the application of 100 g's, and have packed bearings to preclude the possibility of contaminating the suit atmosphere from an external lubrication system. Each of these compressors is rated to deliver 11.44 cfm with a pressure rise of 10 in. of water with inlet conditions of 5 psia and 90 F.

The suit circuit compressor will be started 15 min prior to launch and will continue to run for 12 hr after landing, when the electrical power will be depleted. The compressor will stop only when the pilot is using oxygen from the emergency rate valve while in orbit. Below a pressure altitude of 20,000 ft the compressor will operate continuously to circulate ambient air, regardless of the emergency rate valve operation.

The recirculating atmosphere is sent from the

compressor to the odor and CO_2 absorber, which is designed primarily to maintain the CO_2 concentration in the oxygen stream below the toxic level. The partial pressure of CO_2 is kept at, or below, 4 mm Hg, and under no circumstances will it exceed the level of 8 mm Hg.

The secondary design requirement of the absorber is to prevent the concentration of objectionable odors to an irritating or toxic level.

The absorber, shown in Fig. 4, is a simple rechargeable metal cannister containing activated charcoal for odor absorbtion and lithium hydroxide (LiOH) for CO_2 absorption. It has an operating life of 31 hr.

The charcoal is preceded by a fiber glass micronic filtering and retaining mat encased in wire screening. The flow from the charcoal passes through the LiOH and then through a fiber glass filter where the irritating LiOH dust is collected. The lithium hydroxide is divided into two sections separated by a gas gap. This gap is there to prevent channeling of the flow through the LiOH. To maintain compression on the LiOH granules and on the charcoal, all sections on both sides of the gap are spring loaded.

Now that the atmosphere has been replenished with oxygen and purified, it is sent through the suit circuit evaporator (Fig. 5), where it is cooled.

Water from the cooling water tank is supplied to the suit circuit evaporator through a manually operated water control valve. The water entering the evaporator comes in contact with a woven felt pad of high density, pressed against the face of the core and is thus evenly distributed through the unit.

The core is of plate fin construction with rectangular offset fins, double sandwich single pass on the oxygen side; single sandwich, two pass, on the water side. The water passing through the felt pad comes in contact with the heat transfer surfaces on the water side, where it is spread through capillary action and boiled. As boiling occurs the steam that is generated forces the water vapor out of the first and second passes of the core and overboard through the steam exit duct. The boiling temperature is dependent upon the pressure existing on the water side of the core, which is open to ambient pressure.

The astronaut regulates the water supply during orbit to maintain a comfortable suit temperature. By adjusting the water control valve to increase or decrease water flow, he may raise or lower the suit inlet temperature of the atmosphere. He must be cautious, however, when decreasing his suit temperature, not to allow the steam exit temperature to fall below 50 F, lest the excess water flow freeze in the outlet duct. The pilot must therefore monitor the temperature indicator in the cabin, which receives a signal from a thermocouple at the exit port.

After cooling, the entrained moisture condensed in the suit circuit evaporator is removed in the water separator. The separator, shown in Fig. 6, consists of a sponge which is periodically squeezed dry by a pneumatic piston.

When the sponge is in the collecting position the suit circuit gas passes through it and is relieved of its moisture content. Every 30 min an electrical signal opens a solenoid valve, which allows oxygen to be admitted to both sides of the squeezing piston. A differential area causes the piston to squeeze the sponge for a 30-sec period, after which the electrical

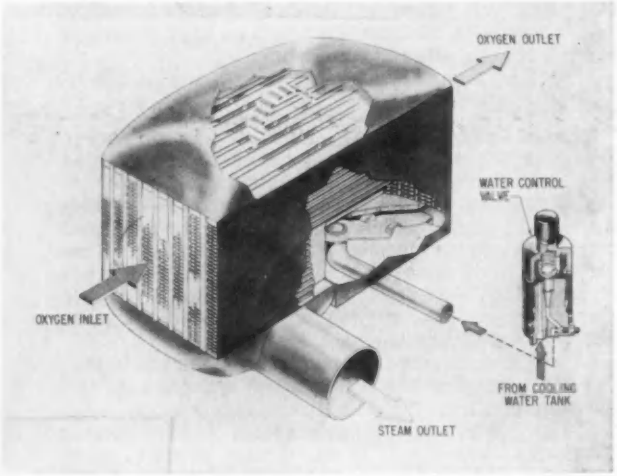


Fig. 5 — Two evaporators in the vehicle use water as the cooling medium and are designed to operate under zero gravity conditions. The water control valve are screw-type needle valves, which may be adjusted by the occupant to control flow of water from the tank.

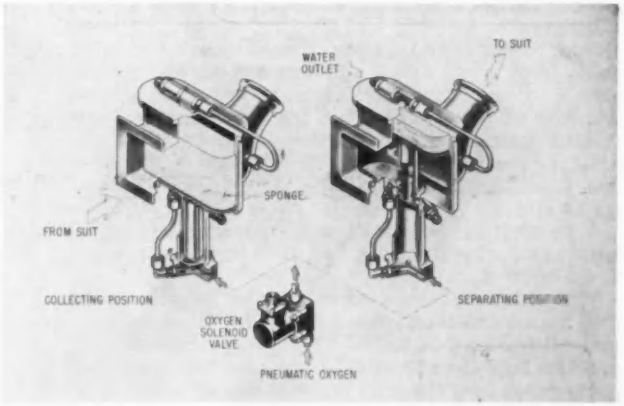


Fig. 6 — Water separator removes the moisture which is condensed in the suit circuit evaporator and entrained in the recirculating gas. It is designed for zero gravity operation and the collecting sponge is squeezed dry every 30 min.

signal is removed. The bottom of the piston is then vented to the cabin through a spring-loaded poppet valve while the oxygen trapped above the piston returns it to its collecting position. The water expelled from the sponge during the sqeezing operation is collected in a condensate drain tank.

During the squeezing period, suit circulation is not interrupted as oxygen continues to pass through the area normally occupied by the sponge.

The solenoid operated valve which controls the operation of the water separator regulates the supply of oxygen to the piston at 100 ± 10 psig from the normal O_2 pressure reducers, or when emergency O_2 is in use, the pressure is maintained at 80 ± 10 psig from the emergency pressure reducer. If leakage occurs past the squeezing mechanism a check valve prevents the depletion of oxygen from the O_2 pressure reducers.

The cabin circuit has an evaporator similar to that of the suit circuit, also controlled by the pilot, to cool the cabin atmosphere. Both of the evaporators are supplied with water from a single pressurized tank which holds 36.4 lb of the coolant. Expulsion of water from the tank, shown in Fig. 7, is controlled by a flexible rubber bladder type liner. Oxygen pressure from the suit inlet manifold is applied to the chamber formed by the gas side of the liner and the inside of the tank, to force water out of the tank to the two manual water controls.

The atmosphere of the cabin circuit is circulated by a single-stage, axial-flow, fan. The fan is driven by a 15-watt, single-phase, electric motor, and will handle an oxygen flow of 30 cfm with inlet conditions of 5 psia and 80 F. It will be started 15 min prior to launch and will stop automatically during descent, at a pressure altitude of 20,000 ft.

After the vehicle descends to the 20,000-ft pressure altitude level, towards the end of the flight, the ground inflow and outflow ventilation valves are opened. Ambient air is drawn in through a snorkel intake valve and fed to the suit circuit along with oxygen from the emergency rate valve. The suit circuit vents to the cabin via the relief port of the suit pressure regulator and the cabin exhausts to ambient through the ground ventilation outflow valve. The ingress of water to the capsule through the ground ventilation system is prevented by the float actuated snorkel, illustrated in Fig. 8.

Prelaunch operation

The flight vehicle is first charged with water and oxygen in preparation for its mission. Then the capsule is mated with the launch vehicle and the cabin is precooled with refrigerated air from a ground cart via a duct through an open entry hatch. Meanwhile, the ground crew connects the suit to the circuit lines and a ground supply of low-pressure oxygen is hooked up to the ground oxygen quick-disconnect coupling. After the occupant closes his helmet face plate, the suit circuit is purged with oxygen from this external source and a suit circuit pressure test is performed.

Before launch the suit circuit compressor and cabin fan are started and a ground supply of Freon 114 is attached to an umbilical coupling to be fed to the suit circuit evaporator for cooling. Water supply to the evaporator is shut off during this period. The ground crew opens the shutoff valves on the oxygen bottles and disconnects the ground oxygen supply. Now the refrigeration air duct is removed from the entrance, the entry hatch is sealed, and a leakage test is run on the cabin hatch.

While on the launch pad the cabin is purged of air with a ground supply of oxygen. No cooling is provided during launch and the capsule heat exchangers do not become effective until a pressure altitude is reached where the boiling temperature of the water is lower than the temperature of the gas entering the evaporators. During this phase the thermal capacity of the precooled structure serves as the heat sink.

This article is based on papers by Edward H. Olling and J. R. Barton.

Ollings' paper is not available in preprint form, but the paper by Barton is available as No. 245B. To order, see page 6.

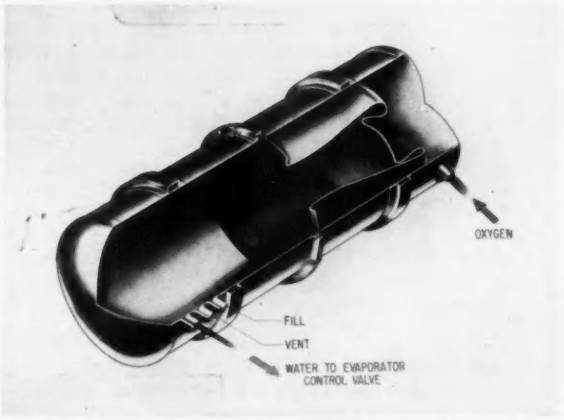


Fig. 7 — Cooling water tank supplies both evaporators. Water is forced from the tank by the flexible rubber bladder, which is pressurized on one side with oxygen.

Fig. 8 — After the capsule has returned to earth and the ground ventilation system becomes operative, the snorkel inlet and outlet valves will admit ambient air into the suit circuit and allow the cabin to exhaust to the surroundings. Water is kept from entering the capsule by the ball float, which acts as a check valve.

Simplicity=success with

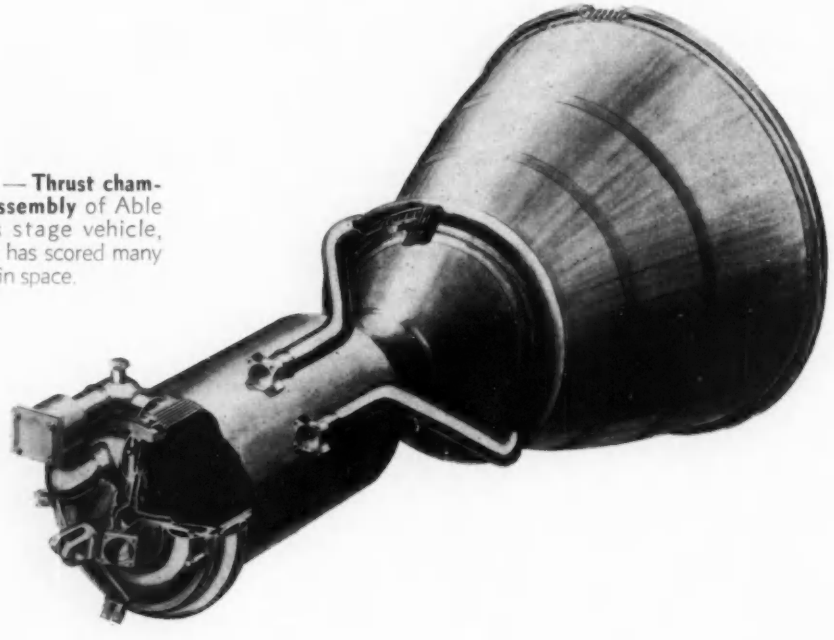


Fig. 1 — **Thrust chamber assembly** of Able series stage vehicle, which has scored many firsts in space.

Able, Ablestar Upper-Stage Vehicles

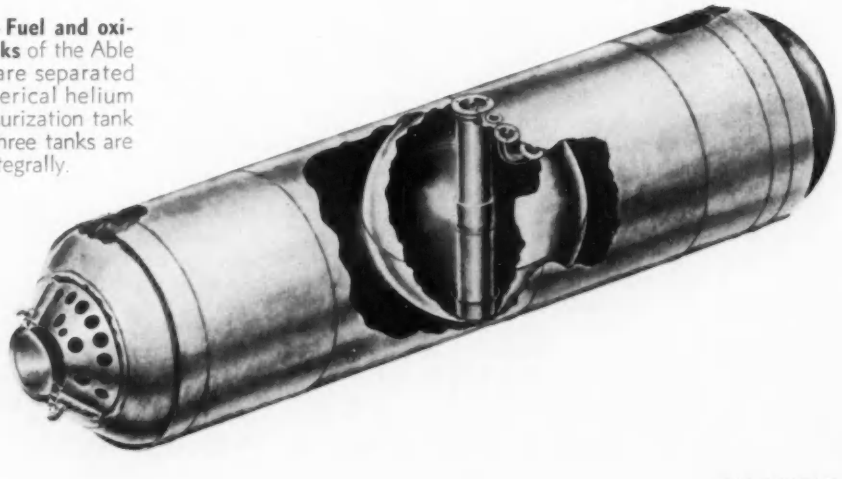


Fig. 2 — **Fuel and oxidizer tanks** of the Able system are separated by a spherical helium gas pressurization tank and all three tanks are joined integrally.

Based on paper by

W. D. Stinnett, J. S. Robbins, and D. Holzman

Aerojet-General

THE ABLE stage vehicle has a regeneratively cooled, aluminum spaghetti tubing thrust chamber with an exit to throat area ratio of 20/1 which operates on a hypergolic propellant combination of white fuming nitric acid and unsymmetrical dimethylhydrazine. The configuration of the thrust chamber assembly is shown in Fig. 1.

The design mixture ratio by weight of oxidizer to fuel is 2.80 ± 0.06 at a chamber pressure of 206 psia. The altitude thrust developed is 7800 lb. A hydraulically actuated, servocontrolled gimbal system is supplied as an integral subassembly of the thrust chamber assembly to provide pitch and yaw attitude control during powered flight. Pitch-yaw control is maintained by orientation of the thrust vector by means of two servo-actuators which rotate the thrust chamber through ±3 deg in either the pitch or yaw plane. A constant hydraulic pressure is applied by a motor-driven pump.

Fuel tank, oxidizer tank, and helium gas pressurization tank of 32-in. diameter are integrally joined and tank ends are hemispherical (Fig. 2). The propellant tanks are designed for a 345-psig working pressure and are pressurized with the stored helium at an initial charging pressure of 1600 psig and supplied through a pressure regulator. The weights of the 410 stainless steel structure and the stored gas are optimized by the inclusion of a solid propellant grain, which augments the pressurization gas.

A roll control system (Fig. 3) utilizes helium gas at regulated pressure to supply restoring moment by means of roll nozzles mounted on the tankage structure skin. Either of a pair of solenoid valves on command, admit helium gas to a pair of clockwise roll nozzles or counterclockwise nozzles as required.

Operating sequence

The sequence of operations upon application of power to the propulsion system is as follows:

(1) The oxidizer thrust chamber valve pilot valve (Item 52 of Fig. 4) is energized, permitting pressurized helium to open the oxidizer thrust chamber valve (Item 15). As this valve opens, the downstream pressure of the valve increases and the oxidizer burst diaphragm (Item 28), used to maintain the thrust chamber oxidizer bleed, ruptures at 90-130 psig, thereby admitting oxidizer flow into the thrust chamber.

(2) When the oxidizer thrust chamber valve reaches 27–28% of its full open position, a mechanical switch (Item 22) is actuated, causing the following events to occur simultaneously:

(a) A mechanical lock in the helium pressure regulator valve (Item 35) is electrically released, allowing pressurized helium to flow into propellant tanks.

(b) The fuel thrust chamber valve solenoid

OF 13 U. S. SATELLITES now in orbit, nine have been boosted into space by Able series upper-stage rockets. The record of successes include:

First to achieve full intercontinental ballistic missile range (5500 nautical miles) carrying the equivalent weight of an operational warhead payload.

• First recovery of a nose cone after a flight over intercontinental ballistic missile range.

• First to project a payload into cislunar space.

• First successful orbiting of a T.V. weather-mapping satellite, the Tiros.

• First to restart in outer space, injecting itself and a navigational-aid satellite into orbit after an initial 5-min boost phase followed by a 20-min coast period.

• Placed Transit 1-B and double-payload, piggyback Transit 2-A into orbit.

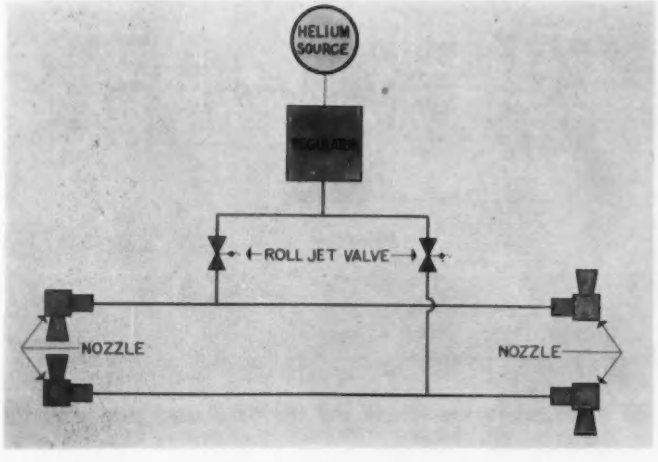


Fig. 3 — **Schematic of roll control system.** Helium gas at regulated pressure is used to supply restoring moment by means of nozzles mounted on tankage structure skin.

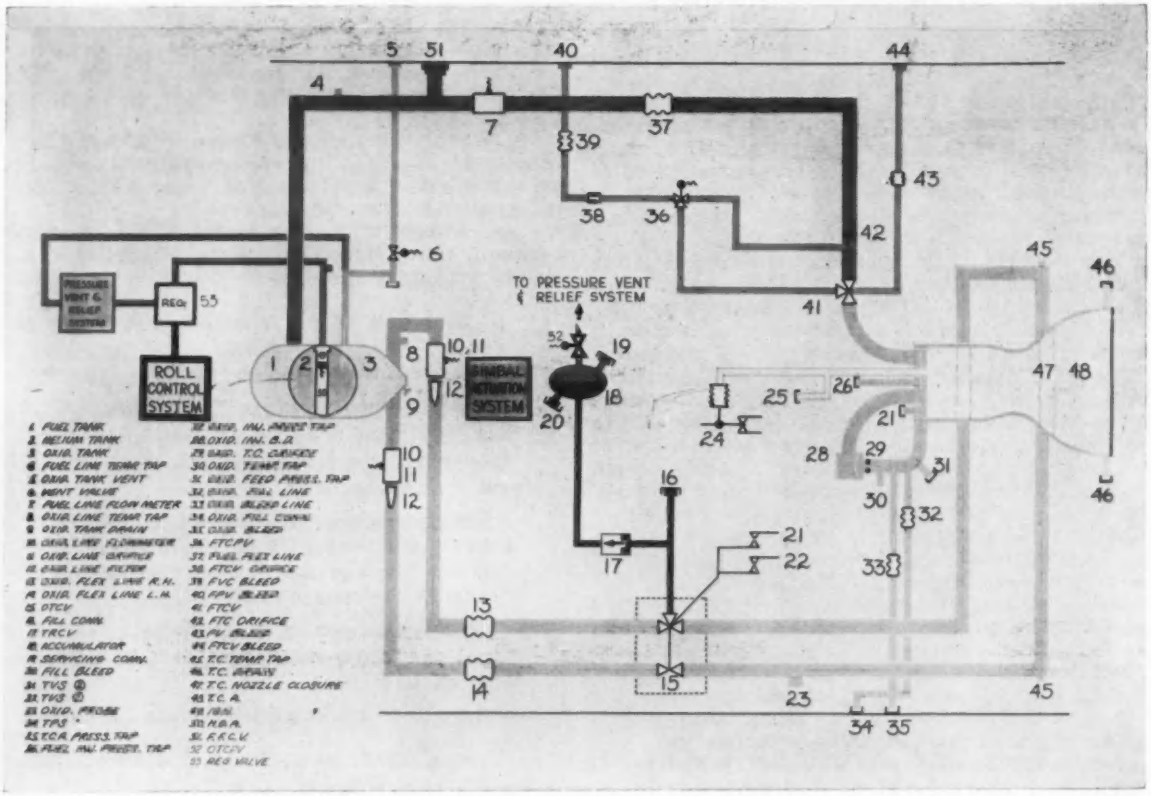


Fig. 4 — **Pressurized propulsion system** of the Able oblique Ablestar eliminates the complicated equipment associated with the turbo pump system and simplifies servicing equipment. Simplicity has brought reliability at low cost.

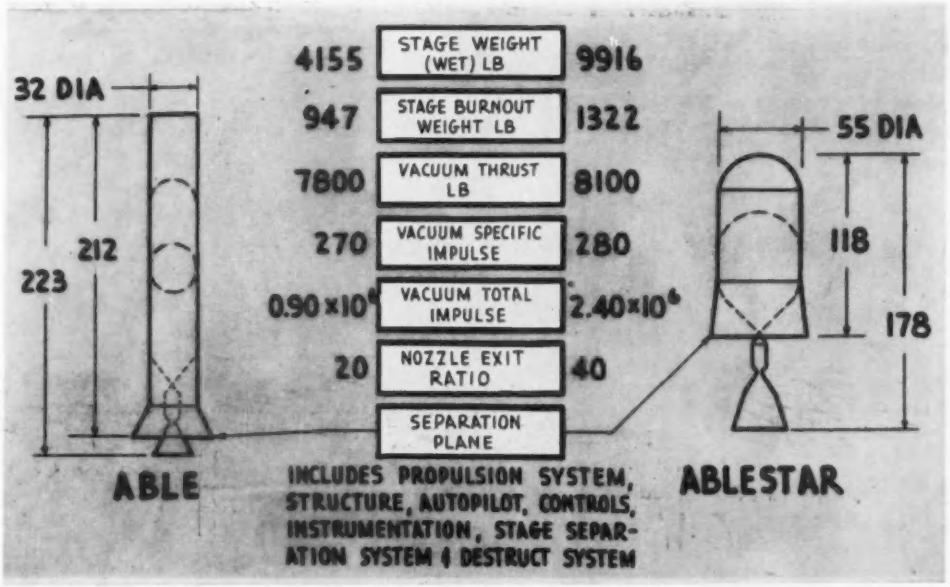


Fig. 5 — **Differences between the Able** upper-stage vehicle and the subsequent more powerful Ablestar.

pilot valve (Item 36) is energized, relieving actuation fuel closing pressure, allowing the fuel thrust chamber valve to open, thereby admitting fuel flow into the thrust chamber.

(c) A 10-sec timer is energized.

(3) The fuel and oxidizer thus admitted to the thrust chamber ignite spontaneously upon mixing. The thrust chamber pressure increases to 108 psig, thereby de-energizing the trip solenoid on the helium pressure regulating valve. Chamber pressure continues to rise to the steady-state value of 206 psig.

(4) When the 10-sec timer expires, the following events occur simultaneously:

(a) The solid propellant grain in the helium tank (Item 50) is ignited.

(b) The thrust chamber pressure switch circuit is armed so that a shutdown will occur in the event of a subsequent decay in the thrust chamber pressure below 100 psig.

Ablestar vehicle design

The Ablestar rocket propulsion system is a logical extension of the Able system. It was developed when studies indicated that a vehicle having 2.5 times the total impulse of the Able system would provide optimum capability above the Thor as a booster. The tank capacity was increased and certain design innovations, born of experience, were incorporated, while the major subsystems of the Able were retained.

The Able and Ablestar configurations are shown in Fig. 5. The major differences in the systems are as follows:

(1) Tank diameter was increased to 55 in. to give more propellant capacity.

(2) The pressurization system incorporates a restart capability.

(3) The oxidizer was changed to red fuming nitric acid because of its storability and increased specific weight.

(4) Pressurization gas storage vessels are no longer integral with the propellant tanks because they are larger in diameter. And they are fabricated from titanium to reduce weight.

(5) The thrust chamber expansion ratio was raised from 20/1 to 40/1 by means of an uncooled titanium nozzle extension. This raised the specific impulse by 10 points and the thrust by 300 lb at a weight increase of only 10 lb.

(6) The thrust chamber does not need oxidizer in the coolant jacket prior to starting sequence.

(7) A cold gas coast attitude control and restart acceleration system was included to provide pitch/yaw/roll control during coast and tank settling just prior to restarting the thrust chamber for satellite injection. The system components have been so oriented into the Ablestar design as to allow their exclusion for missions not requiring restart capability.

Operating sequence of the Ablestar system is virtually the same as that of the Able system except that line valves have been added to the pneumatic system to provide shutdown and restart capability.

To Order Paper No. 246D . . .
from which material for this article was drawn, see p. 6.

Cars Still Balk In Winter Driving

Based on paper by

C. S. Gilbert and E. F. Marshall

Sun Oil Co.

THE majority of motorists do not find much difference in the winter performance of various brands of gasoline, according to a survey made in the Syracuse (N. Y.) and Greater Philadelphia areas.

Starting, warmup, and stalling troubles were cited by motorists from both areas and, surprisingly, complaints of warmup and stalling were greater in number from Philadelphia, the warmer of the two climates. From the information volunteered it is concluded that motorists in cold climates are more apt to allow the engine to warm up before getting underway and so ease the warmup problem. And the fact that many Philadelphia motorists associated stalling with cool, damp mornings indicates carburetor icing to be a significant factor.

Winter trouble is not uniform among different makes of cars. This was determined by breaking down the questionnaire into four classes — cars produced by the three major producers and all others. While there was no very marked difference in the starting and warmup between cars in the four classifications, there were substantial differences in stalling and carburetor icing. Comparison of this survey result with some tests run previously from our laboratory with customers' cars driven by their owners revealed a similar pattern of carburetor icing.

Several conclusions can be drawn from this survey, which elicited 1283 responses divided almost equally between the two areas. They are:

1. Winter performance problems still exist and call for further efforts to improve both engine and fuel design.
2. Winter problems are by no means limited to cold climates.
3. Engine design is a significant factor in the winter performance problem.
4. While the consumer seems not to recognize differences in branded gasolines, the existence of troubles presents a challenge to the fuel designer to eliminate volatility compromises.

To Order Paper No. 264A . . .
from which material for this article was drawn, see p. 6.

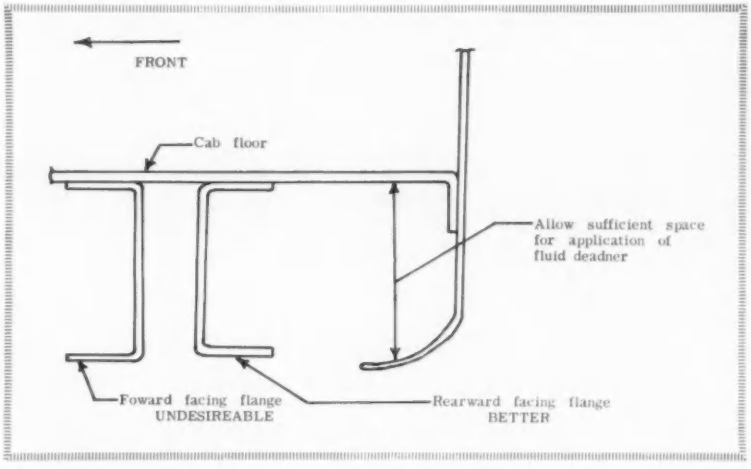


Fig. 1 — EXAMPLES OF GOOD AND POOR UNDERBODY FLANGE DESIGN. Always face flanges away from the nearest wheel and avoid trapping wheel splash.

Stop Truck Corrosion!

Trouble from wheel splash can be minimized through proper design.

Based on paper by

C. O. Durbin

Chrysler Corp.

IT is a relatively simple matter to check corrosion of truck components once the cause is understood. Wheel splash is the worst offender and its effects can be minimized by designing to keep road dirt and deicing salts from accumulating.

Electrical components

Electrical components and wiring have been the worst sufferers from corrosion. Wires for tail and directional signal lamps and connection blocks have been mounted on the top side of the frame rail lower flanges where wheel splash covered them with dirt and salt. With a negative ground battery, the stray electrical current causes severe corrosion of terminals, whereas with a positive ground the frame suffers the corrosion.

There are three ways to reduce this type of corrosion:

- Seal the connectors to keep out moisture.
- Coat the frame with insulating paint.
- Locate the connector where it won't be splashed.

One practical solution is to run the wire along the bottom side of frame rail top flange, or on the side of the rail.

Protection can be given generators by mounting them as high as possible on the engine. Voltage regulators may be mounted on the engine side of the fender side shields or on the dash panel. Ignition resistors can be mounted on the top of the engine or on the dash panel. Minor variations in fender side shield contours can affect engine compartment splash patterns so it is wise to check the mounting locations by proving ground splash tests.

Protection for starters can be had by shielding from splash and by sealing around the starter mouning flanges and other openings into bell housings. This also can be done for starter drives.

Tail lights, parking lights, and directional signals often have to remain in the path of wheel splash. They can be protected in various ways. Mastic-type sealer around mounting screws and socket mounting flanges, and boots on wire conduit will prevent corrosion of sockets. Exposed lamp surfaces should also be enclosed in rubber or plastic boots. Dimmer and stop-lamp switches should be located inside the body of the vehicle. Where this is impractical, use rubber or plastic boots. Careful sealing and boots are needed for terminal connections of two-speed axle shift motors and fuel tank gage sending units.

Preventing body corrosion

Ledges and horizontal flanges below the floor level of truck bodies should be avoided. Flanges should

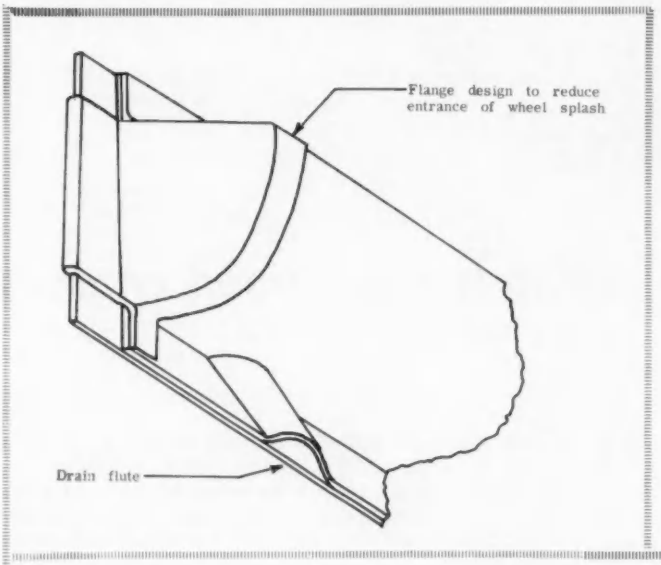


Fig. 2—SILL CONSTRUCTION TO MINIMIZE CORROSION. Drain slopes to rear to avoid plugging. An opening as small as ⅛ in. diameter in path of wheel splash has been known to permit front end of sill to fill with dirt in less than 16 hr of driving.

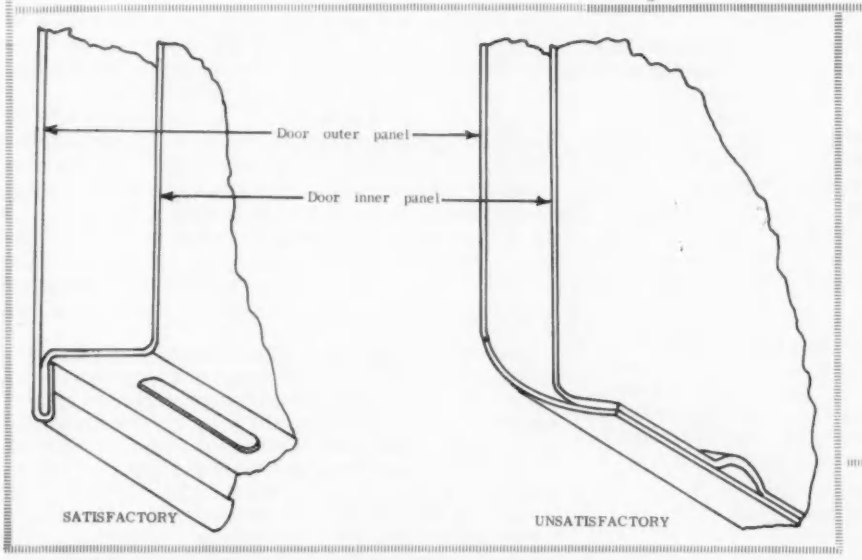


Fig. 3—EXAMPLES OF GOOD AND POOR DOOR DRAINAGE. The unsatisfactory type, when plugged, caused sufficient corrosion to perforate 0.035-in. thick steel in less than 18 months of service.

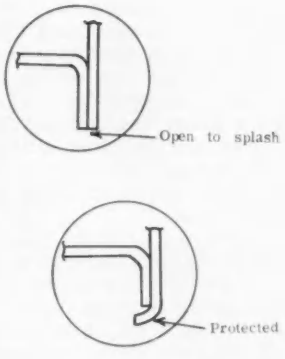


Fig. 4—LAP JOINTS IN LINE WITH WHEEL SPLASH should be flanged for protection.

be narrow and face away from the nearest wheel. Good and bad designs are shown in Fig. 1.

Box sections and enclosed channels should be avoided below the floor. Door sills or rocker panels should be designed to prevent entrance of wheel splash. Sealing of front and rear caps or use of lapping of flanges away from the wheel splash is recommended as shown in Fig. 2. Note that the drain flutes are sloped toward the rear to minimize plugging.

Drain openings are needed on the inside of the outer door panels. Fig. 3 shows good and poor design. Drain openings similar to those used for body sills or doors should be employed wherever there are enclosed surfaces exposed to rain or splash. An example is the space between body inner and outer panels for the sliding doors of panel trucks.

Lap joints in line with wheel splash should be flanged, as shown in Fig. 4 to prevent water, road salt, and dirt from being driven between faying surfaces. When more than one panel is needed to form the undersurface of a truck body, the rear panel should lap over the front one to minimize entrance of moisture and road splash.

Drainage and splash protection will not do the entire job. Protective primers are required for the internal surfaces of doors, sills, and sliding door cavities. Design should permit coating of internal surfaces with exterior body primer.

To Order Paper No. 248A . . .
from which material for this article was drawn, see p. 6.

Coolant heat loss

. . . new measure for rating turbocharged engines

Based on paper by **Robert Cramer, Jr.**
Murphy Diesel Co.

HEAT LOSS to the coolant is an important criterion by which to rate turbocharged engines commercially.

Anyone who has run heat balance tests knows that coolant heat flow measurements are inaccurate — heat balances always carry an item labeled "radiation and unaccounted for." Also, since there are always areas within an engine for heat interchange between the lubricating oil and jacket water, the relative amount carried by each of these does not have much real significance.

The heat which is lost by radiation must first pass through the liners, cylinder heads, or pistons; to evaluate these heat flow quantities, radiation must be included.

However, a direct measure of the total coolant heat flow by difference is possible because the measurement of the other quantities involved in the heat balance is relatively accurate. For purposes of evaluating engines (rather than the duty requirements of radiators, oil coolers, and other accessories) the heat balance need only be broken down into:

1. Energy supplied in fuel.
2. Energy appearing as power output.
3. Energy appearing as friction.
4. Energy appearing as exhaust heat.
5. Energy appearing as water vapor in the exhaust.
6. Energy appearing as coolant heat.

Exhaust heat includes sensible heat used to raise the temperature of the air and burned fuel products. The latent heat carried by water vapor in the exhaust is accounted for by calculation, using the difference between high and low heat value of the fuel. This analysis will be quite accurate in the region of smoke-free combustion. When smoke appears in the exhaust, a correction must be made for the unburned fuel which is not converted into heat.

F. A. Castro in his paper "Quick Evaluation of Thermal Loading of Piston Engines" (presented before the International Internal Combustion Engine Congress at Weisbaden in 1959) applied a similar analysis to a line constructed from measurements of the heat flow to the coolant, the slope of this line being considered as a measure of the thermal load on the pistons and cylinder liners. He developed methods of using these measurements to evaluate heat transfer in the cylinder.

Table 1 and Fig. 1 are typical test data from a naturally aspirated and a turbocharged version of the same engine of 1245 cu in. displacement. Fig. 1 shows characteristic lines for total energy input and lines which break down this input into its four heat flows — power output, exhaust heat, water vapor, and coolant heat. The differential thermal efficiency lines are shown in the upper portion of Fig. 1.

The heat carried by the exhaust is evaluated by measuring the air flow, fuel flow, and the temperature rise from inlet manifold to exhaust manifold. The exhaust temperature measurement must be

Table 2 — Comparative Heat Balance

	Naturally Aspirated			Turbocharged		
	in.-lb/in.^{3}	btu/bhp-hr	%	in.-lb/in.^{3}	btu/bhp-hr	%
Net Output (mep) (I_o)	106	2545	32.0	161	2545	37.0
Friction (I_f)	26	620	7.8	24	380	5.5
Water Vapor (I_v)	16	383	4.8	20	317	4.6
Exhaust (I_e)	90	2150	27.1	136	2150	31.3
Coolant (I_c)	94	2252	28.3	94	1490	21.6
Fuel Heat Input (I)	332	7950	100.0	435	6882	100.0

Table 1 — Typical Test Data

Four Stroke Engine 6⅜ in. × 6½ in. 1400 rpm
Displacement (D) = 1245 in.³

	Naturally Aspirated			Turbocharged			
Load, hp	244	209	132	370	326	243	75
Speed, rpm		1400			1400		
Bmep (Dynamometer), psi	111	95	60	168	148	110	34
Fmep, psi	26	26	26	24	24	24	24
Gmep (I_o), psi	137	121	86	192	172	134	58
Fuel Flow (F), lb/min	1.74	1.36	0.93	2.15	1.87	1.42	0.60
Input Energy (I), in.-lb/in.³	364	283	190	448	390	297	125
Vapor Energy (I_v), in.-lb/in.³	16	13	9	20	18	13	6
Airflow (W_a), lb/min	32.2	32.0	31.5	57.3	52.0	42.5	26.4
Intake Manifold Temperature (T_i), F	78	78	79	281	255	195	120
Exhaust Manifold Temperature (T_e), F	1197	1014	667	1125	1070	930	540
Exhaust Energy (I_e), in.-lb/in.³	102	85	53	136	120	88	31
Coolant Energy (I_c), in.-lb/in.³	109	64	42	100	80	62	30

No. 2 Diesel Fuel H = 19,400 btu/lb HHV

$$I = \frac{HF}{DN} \times 9336 \qquad N = \text{rpm}/2$$

$$I_v = 0.045\, I$$

$$I_o = \text{Bmep} + \text{Fmep}$$

$$I_e = \frac{(T_e - T_i) W_a C_p}{DN} \times 9336 = 2.83 \times 10^{-3} (T_e - T_i) W_a C_p = 0.26$$

$$I_c = I - (I_o + I_v + I_e)$$

taken at a point where the gas is well mixed, not by thermocouples in the exhaust ports. By taking measurements at these points in turbocharged engines (after the compressor, and before the turbine) no correction is necessary for energy recirculated.

At the established rating of the naturally aspirated engine (marked E.R. on Fig. 1) it can be seen that the energy input, I, is 332 in.-lb per cu in. and the coolant heat flow, I_c, is 94 in.-lb per cu in.; the differential thermal efficiency is 25% at a bmep of 106 psi.

In projecting the rating of the turbocharged engine, the coolant I_c will be the controlling criterion; it is equal to the I_c of the naturally aspirated engine at a bmep of 161 psi (marked EQ. R on the graph). At this rating the differential thermal efficiency is 34%, much higher than that of the naturally aspirated engine and so from the standpoint of engine smoke and deposits it would be expected that piston rings, valves, and such would last much longer in the turbocharged version.

This type of analysis can be applied regardless of the rating base — whether this is a continuous duty rating, an intermittent, or a maximum. It is also valuable in comparing different engines; it will indicate whether the relative coolant heat load is high or low.

For comparison, the heat balance of the two engines at the E.R. and EQ. R. points are given in conventional terms in Table 2. These values give no information about the relative thermal loading of the engine parts.

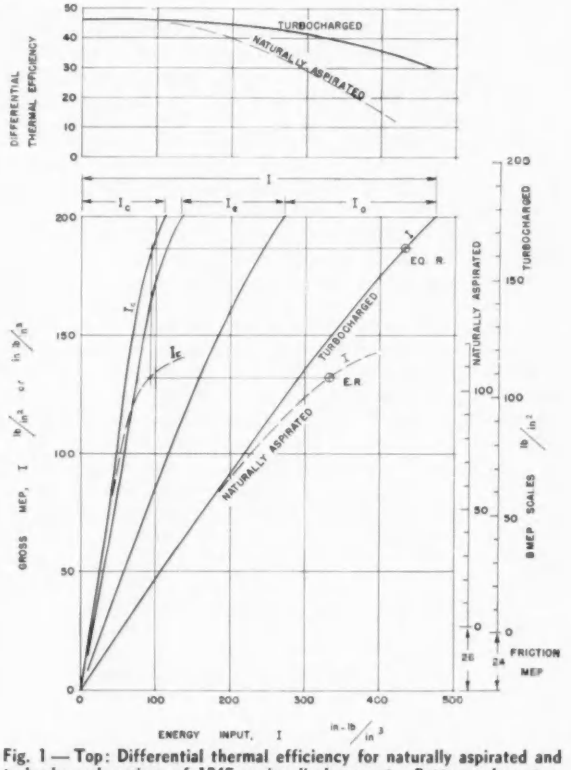


Fig. 1 — Top: Differential thermal efficiency for naturally aspirated and turbocharged engines of 1245 cu in. displacement. Bottom: characteristic lines for total energy input for the two engines and breakdown of this input into its four heat flows — power output (I_o), exhaust heat (I_e), water vapor, and coolant heat (I_c).

To Order Paper No. 258A . . .
from which material for this article was drawn, see p. 6.

Hydrogen promising for space unit secondary power

Hydrogen characteristics best suited for integrating power generation with environmental control.

Based on paper by

D. K. Breaux, W. L. Burriss, and R. L. Schultz

AiResearch Mfg. Co., Division of Garrett Corp.

A HYDROGEN-powered system promises to handle the nonpropulsive, internal power requirements of missiles and space vehicles very efficiently. This system performs best for that very important class of space missions having a duration of from one hour to one month.

Such a power system for the guidance, control, communications and other functions of a space vehicle has numerous advantages, owing to the thermodynamic characteristics of hydrogen. One of the most outstanding of these advantages is the low specific fuel consumption of hydrogen compared to other fuels. The premium placed on low specific fuel consumption, and the resulting lower fuel weight, are what suggest the use of hydrogen as a source of nonpropulsive power. This consideration becomes ever more important with increased mission duration since the fuel weight becomes more of a burden compared to fixed equipment weight.

Desirability of using hydrogen is further enhanced when the problem of heat dissipation is considered simultaneously with that of power generation. Combining the power system with the environmental control system has many benefits, such as more efficient utilization of all available energy, promotion of system reliability and component compatibility. The properties of hydrogen make it an excellent coolant and thus very compatible with this scheme. When heating to room temperature, liquid hydrogen will absorb about twice as much heat as the same weight of water, the usual high capacity coolant. Besides this is the fact that hydrogen may be stored at very low temperatures (40 R). The resulting large temperature differential across the hydrogen heat exchanger will allow savings in size and weight as compared to heat exchangers using water as the coolant.

The optimum system

Fig. 1 is an estimate of optimum power systems, taking system weight into account, to be used for applications where power required and mission duration are given. If the cooling system were to be integrated with the hydrogen-oxygen, dynamic heat engine, power system the range of optimum application of the integrated system would be extended well beyond the range indicated in Fig. 1. Altogether it appears that the hydrogen powered system can suitably meet the major mission requirements for a nonpropulsive power system as dictated by mission duration, power needs and cooling loads.

Furthermore this system is capable of being developed in a relatively short time, which is an important consideration in view of the current accelerated space programs.

How low fuel consumption is achieved

To see just why hydrogen can most readily give low fuel consumption performance, consideration will be given to what is theoretically possible in the way of minimum specific propellant consumption. By definition:

$$SPC = \frac{2545}{\eta_m \, \eta_{ad} \, H_{ad}}$$

where:

SPC = Specific propellant consumption, lb per hp-hr
η_m = Mechanical efficiency
η_{ad} = Adiabatic efficiency
H_{ad} = Adiabatic heat, Btu per lb

Also, for the perfect gas it can be shown that the adiabatic head, or energy per unit mass, is:

$$H_{ad} = \left[\frac{1544}{788}\right]\left[\frac{k}{k-1}\right]\left[\frac{T_{in}}{M_w}\right]\left[1-\left(\frac{P_{out}}{P_{in}}\right)^{\frac{k-1}{k}}\right]$$

where:

k = Specific heat ratio
T_{in} = Expander inlet temperature
M_w = Molecular weight

and

$\frac{P_{out}}{P_{in}}$ = Ratio of outlet to inlet pressure

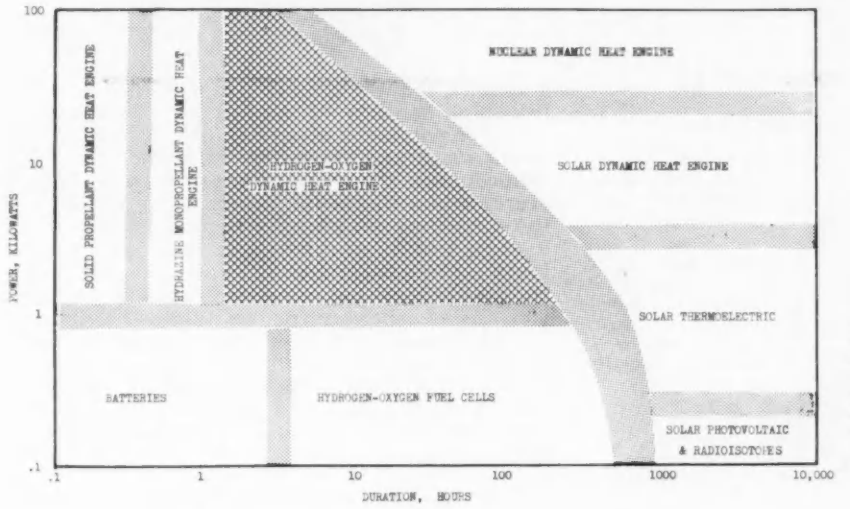


Fig. 1 — Estimate of range of optimum application for several types of power systems. If the hydrogen system is integrated with the environmental control system, the range of application is extended well beyond that shown.

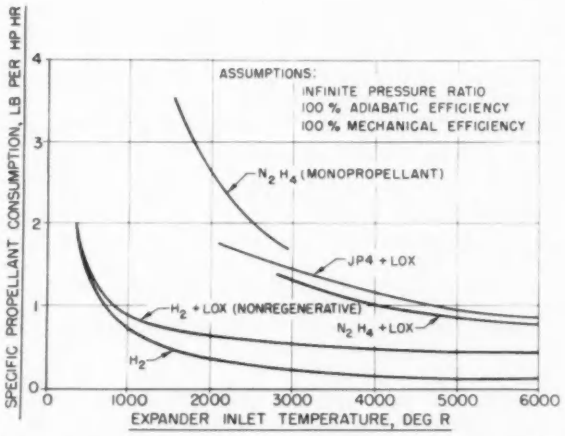


Fig. 2 — Comparison of several propellants under ideal conditions. The lowest curve, representing pure H_2, is seen to be the best propellant, with the hydrogen-oxygen propellant running a close second.

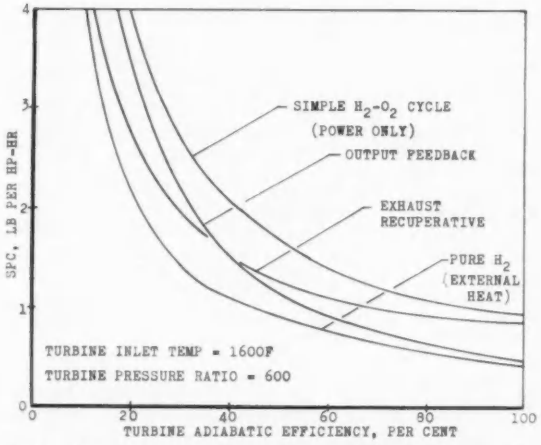


Fig. 3 — Performance of various cycles employing hydrogen as the working fluid. Using external heat exclusively to heat the hydrogen gives the best performance, whereas use of oxygen alone gives the poorest results.

Assuming adiabatic and mechanical efficiencies of 100% and $\frac{P_{out}}{P_{in}} = 0$, we can determine how low the SPC for any fuel can theoretically be for a given inlet temperature. For these conditions SPC = $1282 \left(\frac{M_w}{T_{in}}\right) \left(1 - \frac{1}{k}\right)$ lb per hp-hr. It is clearly seen that the low molecular weight of hydrogen is, in large measure, the important factor in its good performance in the matter of fuel consumption. Of course if hydrogen alone is to be used as the working fluid some means of bringing it to the required T_{in} must be found. Otherwise, it is possible to use a combination of hydrogen and just enough oxygen which, when combusted, will give the required inlet temperature. Although the addition of oxygen increases the molecular weight of the working fluid and thus tends to increase SPC, this effect is minimized because of the high heat of combustion of hydrogen (from two to three times that of JP-4, on a weight basis), in that very little oxygen is required to achieve a given inlet temperature. Typical molecular weight of a hydrogen-oxygen working fluid is 3.1 as compared with 2 for pure hydrogen and 13 for stoichiometric combustion to water.

Figure 2 compares the performance of several propellants when the above ideal conditions are applied. The lowest curve, representing pure H_2, is seen to be the best fluid, with the hydrogen-oxygen propellant running a close second. Although Fig. 2 reveals that it is theoretically possible to achieve an SPC of less than 2 lb per hp-hr with the more conventional propellants such as hydrazine, practical limitations of materials and attainable efficiencies would more likely make the lower limit 3 lb per hp-hr. On the other hand, the hydrogen-oxygen combination can achieve SPC's considerably less than 2 without resorting to extremely high temperatures.

Cycle selection: the integrated system

If the hydrogen propellant is used as a coolant as well as a source of power, not only is the former purpose served but so is the latter because a decrease in SPC can be realized. The hydrogen-powered system actually becomes more efficient when it performs this dual role. This becomes more apparent

Table 1 — Fuel Cell Cooling Capacity

Coolant Top Temperature, F	Propellant Flow Cooling Capacity, % For: SPC = 0.7 lb per hp-hr	SPC = 0.9 lb per hp-hr
100	9.8	12.6
300	13.1	16.8
500	16.0	20.6

Table 2 — Specific Evaporant Consumption and Overall Specific Propellant Consumption for Fuel Cells

Coolant Top Temperature, F	Specific Evaporant Consumption, lb per hp-hr	Specific Propellant + Evaporant Consumption, For Fuel Cell Efficiency of: 65%	50%
100	1.44	2.74	3.59
300	0.99	2.09	2.71
500	0.81	1.82	2.35

Table 3 — Specific Propellant Consumption for the Integrated DHE Power System and Heat Sink

Coolant Top Temperature, F	Integrated Power System and Heat Sink, Dynamic Heat Engine Conversion, Specific Propellant Consumption, lb per hp-hr
100	1.8
300	1.4
500	1.2

when it is remembered that some means must be used to heat the hydrogen to the desired inlet temperature. If oxygen is used to accomplish this heating the molecular weight of the working fluid is increased. The low exhaust pressures encountered in the spacecraft environment allow high pressure ratios to be achieved (above 200) with only moderate inlet pressures. At high pressure ratios SPC, at a prescribed prime mover inlet temperature, becomes a function primarily of prime mover efficiency and fluid molecular weight. It would therefore, be advantageous to use another source of heat instead of or in conjunction with oxygen. For certain applications, such as reentry vehicles, where a high temperature heat source is available, this means of heating the hydrogen looks promising. It is also possible to utilize the prime mover exhaust heat for this purpose (recuperative cycle), or cooling of the prime mover load may provide the heat (output feedback cycle).

How well these various cycles perform is illustrated in Fig 3. As expected, exclusive use of an external heat source gives the best results, while oxygen heating alone gives the poorest results. The recuperative and output feedback cycles lie between these two extremes. It should be kept in mind, when the propellant is to be used as the coolant in the vehicle, that the cooling load, and not the power requirements, may determine SPC. In other words, it may be necessary to increase propellant flow in order to provide adequate cooling capacity. The alternative to this would be to supply a supplemental heat sink. However, since hydrogen has so high a heat sink capacity, much less of it would be required to perform a given cooling job than if a different evaporant, say water, were used.

Advantages other than increased cycle efficiency accrue when the power system is integrated with the environmental control system. Integration, into a single system, of the various fluid loops (propellants, expendable evaporants, and intermediate heat transfer fluids), the associated components (reservoirs, heat exchangers, pumps, valves and controls), and the power equipment, allows maximum use of advanced packaging techniques whereby structure is combined with manifolding and mounting provisions. This results in a minimum of external interconnections and insures component compatibility and system reliability.

Choice of power producing systems

Looking further into the hydrogen powered system it is necessary to choose the nature of the power generating equipment. Consideration will be given to the use of fuel cells, which are static devices, and dynamic heat engines. Despite the inherent thermodynamic advantages of fuel cells, dynamic heat engines have greater applications where the cooling load is such as to require expendable evaporants as a heat sink. This is because fuel cells do not even have sufficient cooling capacity in the propellant flow to take care of the heat load associated with power generation and its ultimate dissipation. The fuel cell itself will generate internal heat equivalent to 54–100% of the electrical power output, corresponding to efficiencies of 50–65% characteristic of these devices. The cooling capability of the fuel cell is shown in Table 1. It is evident, from these figures, that another means of cooling will be required to dissipate 133–190% of the fuel cell electrical output.

Assuming that the additional cooling will be accomplished by the incorporation of hydrogen as the evaporant, the overall SPC for the system would include not only propellant consumption but also evaporant consumption. Table 2 gives values of specific evaporant consumption and the corresponding overall SPC.

The dynamic heat engine, on the other hand, is characterized by its ability to utilize waste heat energy to produce useful output and also by the fact that all the fluid flow, including that provided for cooling, can be expanded in the prime mover. The performance of the dynamic heat engine for the same case as above, where the prime mover output is absorbed by the propellant flow, and assuming a cycle efficiency of 50% (which corresponds to a pressure ratio of 400 and an adiabatic efficiency of 60%) is given in Table 3.

The values given in Table 3 have to be corrected for alternator efficiency, but it is evident that the DHE performance is considerably superior to fuel cells, where heat sink requirements are met by expendable evaporants. In addition, the comparatively high fixed weight of fuel cells places them at a disadvantage relative to dynamic heat engines in short duration applications.

To Order Paper No. 234A . . .
from which material for this article was drawn, see p. 6.

Briefs of SAE PAPERS

Continued from page 6

Penalties of Non-Optimum Flight Operations of Jet Aircraft, A. C. BUTTERWORTH. Paper No. 247B. Penalties involved when jet transport aircraft are not flown in optimum manner and factors to consider affecting time, money, and fuel to airlines which include takeoff clearance, departure control, and effects of variations in cruising altitudes and speeds; reserve fuel and other operational fuel allowances; it is shown that jet transports are capable of earning large profits which can be seriously curtailed if aircraft are not properly used.

Equivalent Wind Concept in Route Planning, R. M. WELLS. Paper No. 247C. Wind models to simulate effect of wind on aircraft operations include contigency wind roses, standard-vector deviation wind aid or retard wind roses, frequency tables, and equivalent headwinds; review of equivalent headwind concept and its use in route planning; reference made to three documents, prepared by Boeing Airplane Co. on equivalent headwinds for 2700 air routes within continental United States, 2000 internationally important air routes, and 2000 strategic air routes.

Electric Computer for Optimum Flight Plan Determination, M. E. BALZER. Paper No. 247D. Development of flight planning computers, planning techniques, and central flight planning weather facility; method of optimum track selection used by United Air Lines in flight planning long range flights for jet transport DC-8; use of Bendix G-15D digital computer capable of defining performance limitations of aircraft involved and selecting best available altitude within framework of ARTC limitations; data input to computer; sample input data sheet prepared by meteorologist is shown.

FUELS & LUBRICANTS

Design of High Compression Ratio Test Engine for Petroleum Industry, B. J. MITCHELL, G. P. RANSOM, H. E. REED. Paper No. 260A. New 371-cu in. V-8 test engine is designed by General Motors as experimental engine suitable for development of fuels and lubricants for higher compression ratios; it operates at 10:1, 12:1 and 15:1 comperssion ratios; method of changing compression ratios; details of combustion chamber, cylinder head gasket, and piston design; engineering tests, endurance and final performance tests.

Fuels for High Compression Engines, B. L. HURD, Jr. Paper No. 260B. Study made at Atlantic Refining Co. to investigate antiknock requirements, both full and part throttle, knock and rumble from deposit ignition, spark plug fouling, and starting knock and hot cranking; two 1956 experimental 12:1 compression ratio engines and one 1959 15:1 engine were used; summary of major findings; with present knowledge, requirements may be met for 12:1 compression ratio level, but not 15:1.

Surface Ignition Survey of New Passenger Cars, E. F. KOENIC, J. R. McLEAN, E. J. BUCHANAN, Jr. Paper No. 260C. Program undertaken at Texaco Research Center to evaluate surface-ignition propensities of current model cars; laboratory technique developed and instrumented and subjective evaluations made to study surface ignition and other abnormal combustion phenomena; data obtained and correlation between them and occurrence of surface ignition in actual consumer service.

Engine Test for Predicting Performance of Engine Lubricants in Most Severe Passenger Car Service, P. A. BENNETT, G. A. MALONE, C. K. MURPHY. Paper No. 261A. Multicylinder engine test developed by General Motors to predict performance of lubricants in current passenger car engines under most severe service conditions encountered by customer; test provides evaluation of lubricant performance with respect to scuffing, wear, rust, corrosion, deposits, and rumble; limitations pointed out.

Test Sequence IV — Measuring Cam and Tappet Scuffing in "Most Severe" Engine Service, E. W. BECKMAN, W. K. FALES. Paper No. 261B. Cam and tappet wear problem encountered in overhead valve V-8 engine; factors affecting problem revealed that engine oil composition was of major importance; development of test technique accepted by Sec. G-IV of Tech Committee B of ASTM Committee D-2 in Oct. 1959 to determine adequacy of lubricant antiscuff properties; scuff rating scale to assist in evaluating test results; correlation with field experience.

Engine Tests for Evaluating Crankcase Oils in Stop-and-Go MS Service, J. G. GAGLIARDI, F. E. GHANNAM, R. F. GASVODA, R. I. POTTER. Paper No. 261C. Details of two laboratory engine dynamometer tests for evaluating oils with emphasis on antisludging, anticlogging, and insoluble suspension characteristics of used lubricant; Sequence V is 3-stage cycling procedure using 1957 Lincoln-Mercury ECU engine; Sequence V-A is cycling sequence evaluating same factors in single cylinder CLR oil test engine; data on reproducibility of tests and correlation with field service.

GROUND VEHICLES

Minimizing Corrosion on Trucks Through Design, C. O. DURBIN. Paper No. 248B. Damaging corrosion is caused by accumulation of deicing salts with road soil in critical areas; how corrosion occurs and how it can be minimized; most serious corrosion is encountered if electric equipment with live terminals is in contact with moist dirt and salt; changing from negative to positive ground, such effects may be transferred from terminals to surrounding metal; body and chassis corrosion prevention; use of sealing or shielding internal surfaces and provisions for drainage and ventilation.

Why Valves Fail, A. K. HANNUM. Paper No. 249A. Paper is intended as guide to analysis of valve failure; flow chart, determining possible causes of valve failures, indicates two major kinds: burning and breakage; two major types of variables contributing to these failures: mechanical and thermal; causes of burning and breaking are examined.

Why Valves Succeed, T. N. TUNNECLIFFE, L. F. JENKINS. Paper No. 249B. Examination of factors other than valve design which influence valve life, such as engine design, chemical environment, engine manufacturing, and maintenance; factors to consider in physical design or shape; evaluation of properties of valve materials and tests to which valve alloys are subjected such as hot hardness, stress rupture, and corrosion resistance.

Winter Operation of Truck and Tractor Equipment in Iron Mining, K. L. PROTHERO, J. E. MEITTUNEN. Paper No. 251A. Winter maintenance problems encountered with 34 and 40-ton diesel powered haulage trucks, 15–25-ton crawler tractors, road graders, etc. used in truck haulage operations at Oliver Iron Mining Div. of U. S. Steel Corp.; climatic conditions, tire traction and road conditions; use of air starters; two improvements in radiators helped to reduce cooling system maintenance; cab and dump body heating; lubrication program, types of lubricants and fuels used; structural failures and preventive maintenance program.

Winterize — Weatherize To Get Most Out of Your Transportation Equipment, L. HARBECK. Paper No. 251C. Program of winterization and use of mechanical aids, such as ether primers for all diesel operating engines, subjected to low temperature starting and operation; use of gas fired, self-contained heaters for winterizing engines

Briefs of SAE PAPERS

Continued from page 85

and batteries, such as gas fired hot water circulating system or hot air system, electrical immersion standby system, and portable space heating pack carried with vehicle; advantages of automatic gas fired system for over road equipment.

Effect of Driver Technique on Vehicle Design, C. A. CARLSON. Paper No. 253A. Manner in which driver operates truck under various conditions of terrain and loading must be considered in design of drive train components which must withstand certain amount of torsional impact; graphs show results of rapid and impact clutch engagements under various conditions; theory and analysis discussed proves that designer must consider that drive train can be subjected to much higher torque values than those represented by maximum engine torque.

Modern Commercial Vehicle and Its Complexities, W. F. EATON. Paper No. 253B. Critical discussion of items relative to maintenance and driving of modern commercial heavy duty tractor, hooked in combination with semitandem axle trailer from viewpoint of Mason & Dixon Lines, Inc.; subjects covered relate to chassis design, air intake system, cab and cab doors; cooling systems, belts, brakes, clutches, etc.

Problems With Commercial Vehicle in Utility Field, W. A. RIGG, R. F. JEIDE. Paper No. 253C. Paper reflects viewpoint of Northern States Power Co., Minneapolis, Minn., and needs of combination electric-gas utility with regard to utility vehicles; operating problems unique to utility field; need for vehicle design modifications to fill specific performance requirements is stressed and improvements desired from operator's standpoint are proposed; driver education and training of operators.

Compact New Caterpillar Diesels, D. W. KNOPF, M. B. MORGAN, F. P. BUTTKE. Paper No. 254A. Design philosophy applied in developing new series of 4-cyl 4 × 5, 4-cyl 4.5 × 5.5, and 6-cyl 4.5 × 5.5 engines; some of design concepts and design aims, problems and solutions, and performance of new engines are presented; particular reference made to design features departing from previous engines; description of major components.

New Techniques in Stress Analysis, R. M. LAW. Paper No. 255B. Use of photostress technique in analysis of stresses in bodies and structures at Detroit Diesel Engine Div. of General Motors Corp.; technique involves coating part to be analyzed with transparent plastic; when load is applied to part, strain is transmitted to coating, which becomes birefrigent; by using white polarized light, color picture of strain distribution is obtained; results of study to determine areas of weakness in newly designed cylinder block; example of study of main hearing web stresses.

Some Notes on Coventry Climax Engines, W. T. F. HASSAN. Paper No. 256A. History of design and development of high performance gasoline engines, ranging from first FW fire pump engines to development of FW engine, and evolution of various types of FW engines; description and specifications of following engines: FWM type engine, FPE 2.5-L V-8 racing engine, FPF 4-cyl engine, FPF 1.5-L engine, etc.; performance comparison of engine types, weight of egines and other data; features common to all engines and others common to twin-cam engines.

Design and Development of Thompson Model 400 Turbocharger, H. MacINNES. Paper No. 257A. Research, design and development of firstThompson turbocharger, Model 16-820 to 400 series for automotive industry; constructional details of Ni-resist turbine housing, divided at inlet into two passages; turbine wheel stress problem was solved by changing to Haynes 151 alloy; results of tests run with volute turbine housing of vaneless nozzle type; modifications of turbine wheel; 400 Series is made with divided and nondivided turbine housings, depending on type of engine used.

Developing Turbocharger for Its Application, J. M. CAZIER, W. S. LANG. Paper No. 257B. Factors influencing small turbocharger design and techniques used at Garrett Corp. in developing turbocharger journal bearings and rotors; influence of engine application on turbocharger aerodynamic design requirements is discussed with examples relating to 4-cycle diesel engine, turbocharging vehicle engines for lugging operation, etc.; other factors such as installation factors, ambient air pressure, and temperature variations.

Evaluating Performance and Heat Rejection of Turbocharged Engines, R. CRAMER, Jr. Paper No. 258A. Weakness of accepted methods of presenting energy relationships in internal combustion engines pointed out; plotting relationship of input and output energy at given engine speeds yields revealing characteristic lines, free from extraneous influences which mask performance; by breaking down input energy into four principal heat flows, additional insight is gained into factors which determine acceptable engine rating; application of technique to evaluation of best components shown.

Cummins New PT Fuel Pump, N. M. REINERS, R. C. SCHMIDT, J. P. PERR. Paper No. 258B. Objectives of concurrent development of engines and fuel systems at Cummins Engine Co.; design of PT fuel pump in which fuel pressure for metering is controlled by action of governor; pressure time (PT) principle: quantity of fuel metered into injection cavity through fixed metering orifice is determined by fuel pressure differential across orifice and total time that orifice is open as fixed by cam-actuated plunger; fuel pump components; pressure and total flow control; controlling engine torque curve.

Piston Rings for Transportation Diesels, G. F. HYDE, F. A. ROBBINS, P. R. SHEPLER. Paper No. 259A. Data on metallographic, chemical, and mechanical properties of gray cast irons, malleable cast irons, ductile irons and steel materials used; bare iron rings in iron liners exhibit high wear rates for both cylinders and rings, iron rings in chromium plated liners show reduction in wear, chromium plated rings in iron liners show even more reduction; typical piston ring arrangements and salient metallurgical considerations.

Development of American Marc Opposed-Piston Two-Cycle Diesel Engines, A. LUERKEN, K. SOMHEGYI. Paper No. 259B. Background and development of line which includes engines of 9, 19, and 21-cu in. displacement as portable generator sets and outboard engines; basic layout and details of running gear, scavenging, injection, and lubrication system; air-cooled engines have finned cylinders, axial fan, and shroud; water-cooled engines have jacket around cylinder and double walled exhaust manifold; development problems.

ALSO AVAILABLE

1960 SAE TRACTOR PRODUCTION FORUM . . . SP-332 consists of reports on 9 panels, as follows:

Heat-Treatment by R. C. Onan, secretary. The improvements effected by continual change and refinement in the many sided field of heat-treating sometimes approach the spectacular. Among the topics discussed are: Furnace maintenance as it affects quality; Atmosphere in heat-treating; High-temperature carburizing; Plain carbon hardenability; and Quenching treatment and machinability.

Unique Manufacturing Processes by S.

K. Rudorf, secretary. Unusual processes are a new means of cost reduction. Descriptions of electrolytic grinding, burring, roll burnishing, boring, semi-automatic loading, impact machining, and spline rolling are given.

Gear and Spline Design and Production by L. F. Crystal, secretary. Clear terminology, specifications clarification, and standardization have long been needed by the designer to assure that Manufacturing and Quality Control are fully aware of the design intent. This can be helped by: proper and standard specifications; Product Design, Manufacturing, and Quality Control cooperation; use of existing standards; improvement and expansion of existing standards; improved in-inspection techniques; increased percentage of parts inspected (automated inspection); better understanding of effect of blanks on final gear quality; improved heat-treat control; improved quality control of tools; training programs and specialized personnel; and as gears and splines are required to carry greater loads and fit into smaller areas, all these factors become more and more important.

Welding Methods and Process Control by E. H. Lundby, secretary. Experts discuss low and high-alloy steels; manufacturing procedures and process control; surfacing and automation; heavy fabrication and fixture design; weld design and process evaluation; inert gas and CO_2 — equipment and procedures; resistance welding — design and procedures; and welding metallurgy and cast irons.

Production Control Tools for Scheduling and Shop Loading by J. A. Chobanian, secretary. The increased complexity of today's products, the high cost of labor and machine tools, and customers' demands for delivery service are all making the function of scheduling and loading increasingly important. Areas considered include: punched card systems; utilization of computers; determining manpower and machine tool requirements; and special problems of job shops.

Production Problems of Small Engines by J. G. Boehm, secretary. Problems such as costs, service to customers, and cooperative effort within the organization are dicussed. Also covered are: inventory control (material and parts); engineering and manufacturing problems peculiar to small engines; packaging and shipping; effect of material-handling techniques on production rates and costs; how to time and enforce engineering changes effectively; painting.

Precision Tooling for Job Shop Operation by W. D. Clark, secretary. Discusses precision tooling for large forged, cast, and fabricated parts; automation applied to tool and die making; tooling for short-run sheet metal parts; and tooling for short-run production of precision instruments used in airborne vehicles.

Engineering-Manufacturing Relationships by E. S. Evans, secretary. Areas considered on effective liaison between engineering and manufacturing include: engineering-manufacturing coordination; understanding each others' problems; establishment of effective coordination and proper communications; and maintaining effective coordination and proper communications.

Operating Experience with Numerically Controlled Machines by M. J. Steinbraker, secretary. Tape-controlled machines are now in day-to-day use on the production floor. How have they worked out? Among topics considered are; cost analysis of typical parts; impact on engineering and plant personnel; reliability and servicing records; unexpected problems; preparing for numerical control; and management's reaction to new machines.

What Operators Want in Containers

Based on paper by

E. B. OGDEN
Consolidated Freightways, Inc.

UNTIL containers are standardized, their use will be limited to captive operations. And as long as this is the case, the economic advantages to be had from using containers cannot be fully realized.

There are ten things operators want and must have if containers are to be economical. They are:

1. Standardization of container sizes.
2. Methods of handling to be standardized between highway, rail, and water transportation.
3. Lower rates for containers than for semitrailers of the same size when tendered to other forms of transportation because of weight reduction due to removal of wheels, axles, springs and the like.
4. Shipper to join willingly to work out a better freight handling method so as to improve service, reduce cargo damage, and lower the manhours per pound of freight moved.
5. Simplicity in container design to reduce maintenance cost.
6. Design for maximum cubic capacity.
7. Design that results in minimum weight increase over standard semitrailers of similar size.
8. Reasonably easy methods of fastening together two 20-ft or four 10-ft containers to give a 40-ft overall for long highway hauls.
9. A means for keeping containers mobile in their own and shippers' yards.
10. Overall investment in equipment to be an economy rather than an added burden. This could be accomplished by standardizing the methods of attaching the bogie assembly to the container so that anyone's bogies could be used for hauling. It would also simplify interchange.

Containers are not going to cause a revolution in freight handling. They are going to come into use by the process of evolution. Containers are not really new. A semitrailer as now developed is about as handy a container as there is.

■ **To Order Paper No. 299C . . .** from which material for this article was drawn, see p. 6.

Economy Sets Powerplant Trends

Based on paper by

JOHN S. WINTRINGHAM
Ethyl Corp.

Material drawn from an
SAE Fort Wayne Section Paper

WEIGHING the advantages and disadvantages of various powerplants leads to the conclusion that the conventional gasoline engine is not likely to be replaced for passenger car use. What the public now wants is more miles per dollar and this is already influencing the size of engines in large cars and the weights and dimensions of those cars.

At the end of 1959 there were 56.5 million cars in use. Of this number 1.4 were imports and 1.0 were U. S. compacts. Small cars, therefore, accounted for 4.2%. By the close of 1964, the number cars in use will rise to 71.4 million, according to estimates. Of these 3.9 million will be imports, and 7.8 million will be U. S. compacts. Thus, the car population will contain 16.4% of small cars.

In spite of this growth in number of small cars, there will be more full-size cars in 1964 than in 1959, and the demand for gasoline will grow. Estimates put the increase in demand at 18% in the next five years, a rise from 57 to 67 billion gallons.

■ **To Order Paper No. S275 . . .** from which material for this article was drawn, see p. 6.

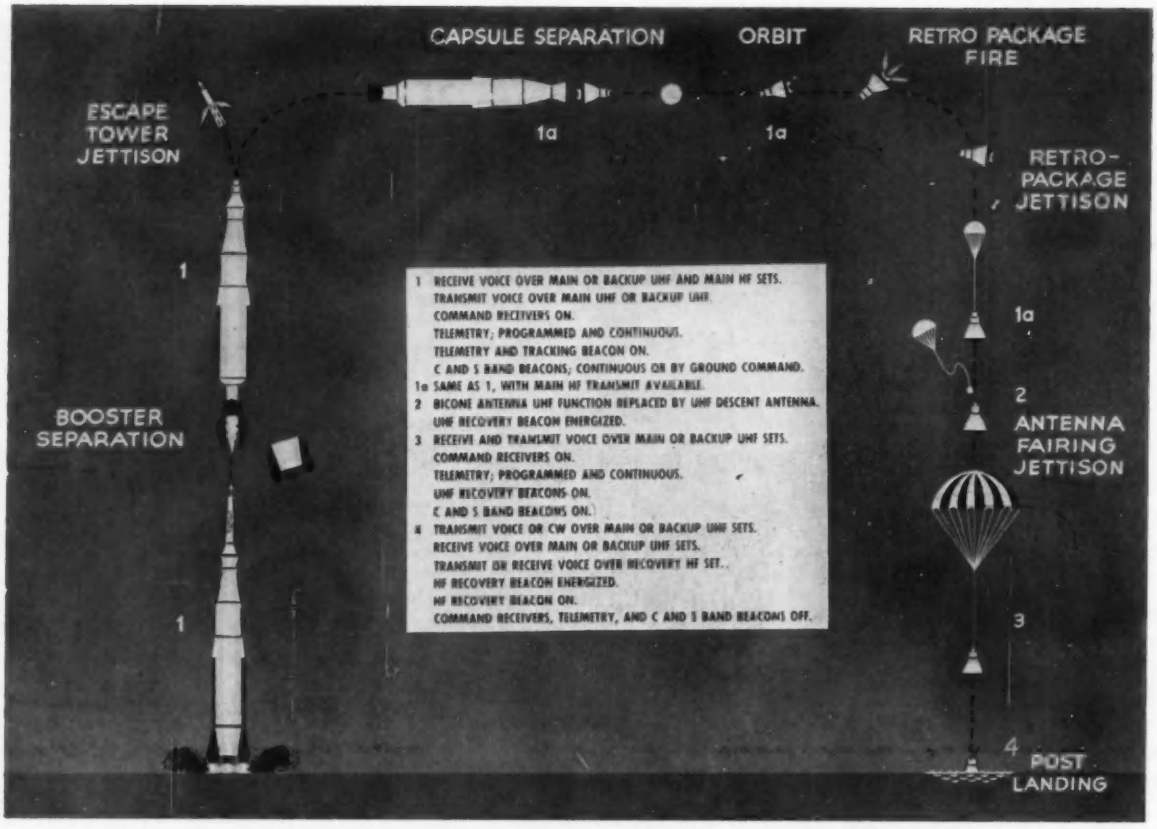

CAPSULE SEPARATION
ORBIT
RETRO PACKAGE FIRE
ESCAPE TOWER JETTISON
1a
1a
RETRO-PACKAGE JETTISON
1
1a
BOOSTER SEPARATION
2
ANTENNA FAIRING JETTISON
1
3
4
POST LANDING
1 RECEIVE VOICE OVER MAIN OR BACKUP UHF AND MAIN HF SETS.
TRANSMIT VOICE OVER MAIN UHF OR BACKUP UHF.
COMMAND RECEIVERS ON.
TELEMETRY; PROGRAMMED AND CONTINUOUS.
TELEMETRY AND TRACKING BEACON ON.
C AND S BAND BEACONS; CONTINUOUS OR BY GROUND COMMAND.
1a SAME AS 1, WITH MAIN HF TRANSMIT AVAILABLE.
2 BICONE ANTENNA UHF FUNCTION REPLACED BY UHF DESCENT ANTENNA.
UHF RECOVERY BEACON ENERGIZED.
3 RECEIVE AND TRANSMIT VOICE OVER MAIN OR BACKUP UHF SETS.
COMMAND RECEIVERS ON.
TELEMETRY; PROGRAMMED AND CONTINUOUS.
UHF RECOVERY BEACONS ON.
C AND S BAND BEACONS ON.
4 TRANSMIT VOICE OR CW OVER MAIN OR BACKUP UHF SETS.
RECEIVE VOICE OVER MAIN OR BACKUP UHF SETS.
TRANSMIT OR RECEIVE VOICE OVER RECOVERY HF SET..
HF RECOVERY BEACON ENERGIZED.
HF RECOVERY BEACON ON.
COMMAND RECEIVERS, TELEMETRY, AND C AND S BAND BEACONS OFF.

Fig. 1 — Communications sequence of Project Mercury keyed to flight phases when man is orbited around the earth.

Communications Vital Link In Orbiting Man around Earth

Based on paper by

WILLIAM BENNER

McDonnell Aircraft Corp.

WHEN Project Mercury puts a man in orbit around the earth and brings him back in a ballistic re-entry, communications, which include not only voice links but command links, telemetry, and tracking beacons, are going to play a vital role.

Launching, orbital flight, and landing of the capsule are depicted in Fig. 1 with communications sequence. Redundancy and diversity of operation of communications links are provided for the capsule when in orbit. Similar safeguards are there for the recovery phase where both h-f and ultra-h-f are used with two different units in each band and two separate antenna systems, with both automatic and manual control.

Computed trajectory data, telemetry data, and other forms of communication will be funneled through the control center at Cape Canaveral which has the following functions to perform:

- Direct the flight from all aspects.
- Monitor the flight from both the aeromedical and the capsule-system point of view.
- Make decisions to abort the mission, depending on orbital characteristics and capsule status.
- Command re-entry.
- Keep astronaut and range stations informed of progress.
- Coordinate all range stations and maintain flow of information to all units involved.
- Supply information and alert recovery forces when decision has been made to start re-entry.

An early capsule is shown in Fig 2. It has one primary antenna for launch, orbit, and re-entry phases. It is an outgrowth of a so-called bicone, the aperture running around the capsule between parachute and drogue chute compartments. Actually, this antenna is in the form of a disc on top the point of a cone (discone) but still gives 360-deg coverage for ultra-h-f signals, at right angles to the vehicle. It also serves to isolate the drogue chute area from the remainder of the capsule skin so that the two metal areas can be fed on h-f as an unsymmetrical "dipole."

Because of the high frequency of the radar tracking beacons and their need

Fig. 2 — Capsule showing escape tower resting on parachute compartment and surrounding drogue chute compartment with bicone in between. Dark band is flush radome over aperture. Radar tracking transponder antennas (C- and S-band) are on capsule skirt; descent and recovery antennas are under cone of bicone. Opening in skirt shows where astronaut sits.

to function without interruption, a separate antenna system is used. Three sets of flush-mounted helices, one for each S- and C-band, per set, are spaced equally around the capsule below the parachute compartment, where they are undisturbed by the escape tower or bicone jettisoning. R-f leads are more direct, and the structure can tolerate better the inset of the units.

This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.

Costs Control Future Of Transport Helicopter

Based on paper by

L. L. DOUGLAS, Boeing Airplane Co.

WHEN the direct operating costs of five types of helicopters and VTOL aircraft are compared with those of the modern fixed-wing transport of approximately the same size (using existence experience to project initial and maintenance costs), the analysis leads to these conclusions:

1. At a range of 100 nautical miles the helicopter has a direct operating cost approximately twice that of the comparable fixed-wing aircraft.

2. Below 100 nautical miles, fixed-wing aircraft operating costs rise rapidly and at 32 nautical miles they become equal to those of the helicopter.

3. If the initial and maintenance costs of the helicopter could be reduced through technical developments to a point half way between those of the fixed-wing aircraft and its present level, the direct operating costs of the helicopter at 100-nautical-mile range become approximately 126% those of the fixed-wing aircraft.

4. The potential of compound helicopters and VTOL tilt-wing aircraft approaches the direct operating cost of the fixed-wing aircraft for the longer ranges, and provides the lower operating costs of the helicopter for the shorter ranges.

■ **To Order Paper No. 266F . . .** from which material for this article was drawn, see p. 6.

Guides to Training Devices for Space Crews

Based on paper by

G. F. RABIDEAU

Space Technology Labs., Inc.

and

D. L. SCHLOREDT

Norair Division, Northrop Corp.

WITHOUT guides for determining the quantity and character of training devices for manned space flight, the shotgun approach is likely to be used, resulting in numerous complex devices of dubious value.

With the objective of providing some guidelines to aid in solving training problems, seven hypotheses are presented with some supporting data:

1. The most critical training device problems will be those pertaining to space crews.

This is so because the precise nature and effects of space environmental factors on the welfare of space crews and their ability to perform needed functions will not have been determined adequately by the time multiman space systems are under development.

2. Training to adjust to space environments and to perform tasks efficiently in such environments must entail the use of devices which simulate certain environmental deviations.

Obviously, it is impractical to attempt to attain a performance figure for every combination of abnormal environmental factors, and it may be unnecessary to plan extensive training with the aim of maximizing capability under such conditions. However, it is important to indoctrinate space crews so that they are familiar with the effects of environmental factors and can predict their own performances under such conditions. Where control action is required, either to normalize the environment or for other reasons, extensive training is in order.

3. Space crew training of certain types can be achieved effectively with relatively simple devices at ground "holding" (and training) facilities.

Imposition of a rule of parsimony with respect to the physical fidelity with which environmental forces are simulated in space crew training device design will result in a number of part-task trainers, as defined by R. B. Miller,[1] each of which provides physical simulation only to the extent deemed necessary to provide the amount of psychological stimulation necessary for effective transfer of training to the functional demands of the operational space vehicle environment. As Miller has pointed out, there is an optimum degree of physical simulation which provides maximum transfer of training value per dollar of training and training device cost. Beyond this point the gains in training value diminish relative to the rapid increments in cost of simulation.

4. Need exists for the design of training devices for use in space vehicles or stations, or both, to maintain seldom-used but critical skills.

Many emergencies requiring prompt decision and action by the operator might occur with an orbital vehicle. If re-entry and landing are to be done under operator control, successful ac-

Continued on page 123

[1] "Handbook on Training and Training Equipment Design," R. B. Miller, WADC Technical Report 53-136, Wright Air Development Center, June 1953.

High-Temperature Lubes Studied for Space Vehicles

Material drawn from an

SAE Spokane-Intermountain Section Paper

Based on talk by

E. N. KLEMGARD

Institute of Technology,
Washington State University

BY a combination of pressure and rubbing of the surfaces with solid-phase lubricants in suitable adhesive agents, nickel alloy or ceramic-metallic bearings surfaces can be produced under dynamically controlled absorption processes, which greatly reduce kinetic friction and wear. This is one of the conclusions reached from development work at Washington State University on dry film lubricated ball bearings for use on space vehicles operating at – 65 F through 1500 F.

This program involves fundamental studies of: solids having low anisotropic shear values over this wide temperature range, and the basic mechanisms controlling adhesion and diffusion at the bearing surfaces and substrates.

Fig. 1 illustrates the important fundamental factors under study in regard to dry film lubricants. This diagram shows in a simplified form a model of the modes of joint action as a network of interrelated complex fundamental processes, found in solid state lubrication to 2000 F. Results at Washington State University have shown that certain graphite edge compounds can be synthesized that have shear values of only 0.53×10^8 dynes per cm^2, under heavy loads at 1700 F, as compared with values of 1.15–2.07 for different graphites alone.

Other layer lattice compounds and intercalated compounds are showing considerable promise in meeting the desired goals. Evidence is also being obtained that chelation compounds formed with metals in the bearing surface can also produce improvements in the dynamically absorbed films.

Alternators Tops For Small Engines

Based on paper by

W. O. HENSCHKE

R. E. Phelon Co., Inc.

ALTERNATORS offer many advantages in small industrial and marine engine applications. One of these is the simplicity with which they can provide both alternating and direct current output.

The alternator system may be single or polyphase, use a magnetic or nonmagnetic enclosure, have an electromagnetic or permanent-magnet field, be designed with both field and generating structures stationary or with one of these members moving.

The use of permanent magnets as a source of field energy permits a simple design with a rotating field structure, which requires no sliding contact arrangement. The design problem is also simplified, since no field energy is required from the source. A typical electromagnetic field requires 3 amp at 14 v or 42 w, which energy must be supplied before there is any useful output.

Permanent Magnet Advantage

Assume a specification requiring an alternator to deliver 8 amp to a 12-v system (14 v) at 800 rpm. This is a useful load of 112 w. If the field requires 42 w, the alternator must be designed to produce 144 w at 800 rpm, or 37.5% more energy than if the design employed permanent magnets. The gain in efficiency with a permanent magnet field becomes more obvious in smaller machines than in large units and as low-speed requirements become more stringent. The flywheel alternator has added efficiencies in comparison with remote devices, particularly on small engines. The elimination of belts, separate bearings beyond those needed for the engine itself, and sliding contacts, all lead to greater useful horsepower. While not large in themselves, these factors may represent an appreciable part of the power available from an engine rated at 2 hp.

■ **To Order Paper No. 276C . . .** from which material for this article was drawn, see p. 6.

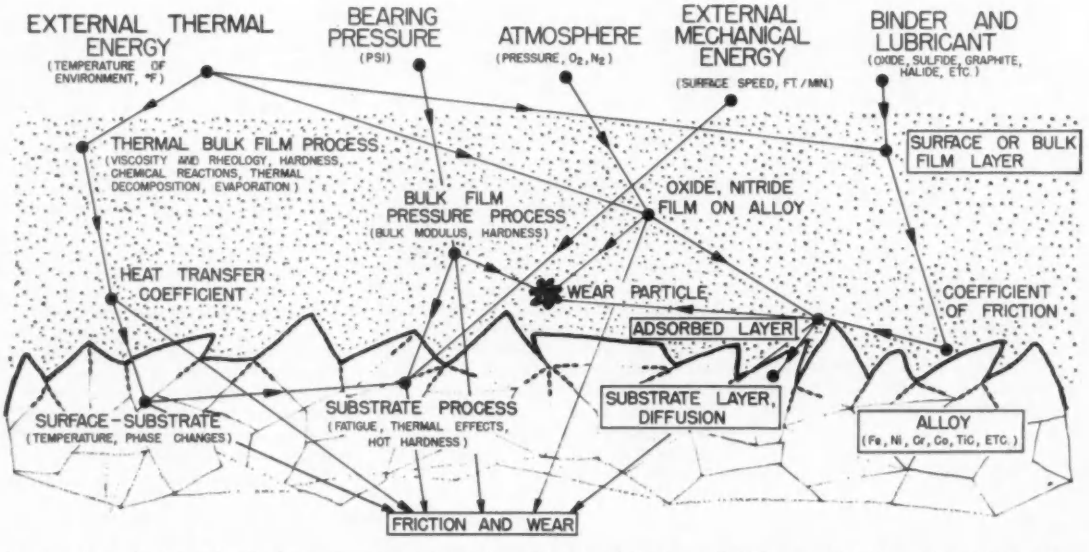


Fig. 1 — Network of complex fundamental process representing solid state lubrication to 2000 F — model of the modes of joint action.

SAE NEWS

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. . . Rambling Through The Sections

The NULL-GRAVITY SIMULATOR which is being developed by Lockheed is expected to extend the experience of weightlessness for human subjects to many minutes, hours, or days. It operates by depriving the subject of all his cues — visual, mechanical, and inner-ear balance organ — to the existence of a gravitional field, and by reducing the amount of his required physical work to nearly zero. This is accomplished by enclosing him inside a tank which is full of water, to nullify work, visual, and mechanical cues; and by spinning the tank, water, and subject to nullify inner-ear cues, Dr. Raphael B. Levine of Lockheed Aircraft Corp. told **ATLANTA SECTION** at their November meeting.

FIVES MAKES of aluminum engines are in production this year and a sixth is coming, James M. Smith of Aluminum Co. of America mentioned at **SOUTH BEND DIVISION, CHICAGO SECTION** on November 21.

In 1950 only 10 lb of aluminum were used in the U. S. automobile. By 1960 the average rose to 65 lb, and this year 750,000 tons of aluminum will be used by the auto industry.

FUTURE LAND COMBAT equipment must have the ability to move rapidly — within hours — a small striking force of soldiers including logistic support within an operating radius of 150 miles, as opposed to the World War II requirement of 20–50 miles a day, Murray Kamrass of Cornell University stated at **WICHITA SECTION** November 17. (Kamrass' presentation was a result of a study by Cornell Aeronautical Lab. and was not an official U. S. Army requirement.)

PAST CHAIRMEN'S NIGHT was the main attraction at **BRITISH COLUMBIA SECTION'S** November meeting. Former Section Chairmen who were present included (front row, left to right) E. C. Howell (1952); J. B. Mortimer (1954), automotive service engineer; P. J. Schrodt (1946) of British Columbia Electric Co., Ltd.; H. D. MacDonald (1947) of Fred Deeley, Ltd.; S. G. Jones (1960) of Imperial Oil, Ltd.; and (back row) L. B. McPherson (1955) of Truck Parts & Equipment, Ltd.; A. W. Phillips (1956) of Automotive Electric Service (Pacific), Ltd.; C. H. Willis (1957) of Home Oil Distributors, Ltd.; Alan Reid (1953) of Wolf Chevrolet-Oldsmobile, Ltd.; Prof. Lionel Coulthard (1959) of University of British Columbia; and Harold Puxon (1948) of Columbia Trailer Co.

PASSENGER JET AIRPLANES DO NOT compare favorably with propeller types in certain respects and a definite need for improvement in these particular areas is indicated, William Littlewood of American Airlines told **SOUTHERN NEW ENGLAND SECTION**, October 25.

On the ground alone, the jet is like a whale on the beach because of its inherent immobility in closed-in distances, the required taxiing and detailed checking of instruments. New York is 25 minutes closer to Chicago by prop plane than by jet because of starting and end losses for the trip.

Suggested for the future is some reasonable degree of airport standardization or layout. Along with emphasis on increased training and skill of personnel, units with the aircraft as a package should be made more easily accessible for both on-ground and in-flight servicing.

NEW HIGH SPEED PUMPS and compressors, which are being developed to operate at gas turbine shaft speed, eliminate any requirements for speed reducers and result in a complete package that is only a fraction of the size and weight of units powered by reciprocating engines, Pierre Valkmar

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of Aero Research Mfg. Co. stated at **TEXAS GULF COAST SECTION** at their November meeting.

IT MAY BE 15 YEARS before there is wide application of fuel cells, Dr. Manuel Shaw of Electric Autolite Co. told **ONTARIO SECTION** November 16.

Although fuel cells offer a number of advantages including silence in operation — as there are no moving parts in the power plant — and greater efficiency than is obtainable from conventional sources of power, they also involve certain problems. Since the most efficient fuel cells are those that operate at high temperatures, there is a need for those that operate at near-normal temperatures and on readily available fuels.

SAE FACULTY ADVISOR Prof. Orville C. Cromer (above right) of Purdue University received a certificate of appreciation for long and faithful service to SAE at **INDIANA SECTION** November 17. Section Chairman D. D. DonCarlos (left) made the presentation.

Section Meetings

BALTIMORE

February 9 . . . K. C. Kresge, Socony Mobil Oil Co. "Lubrication of Two-Cycle Gasoline Engines." Elks Club, 307 W. Fayette St. Social Period 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

INDIANA

February 16 . . . Gale R. Beardsley, manager, engine & electrical section, project engineering, Ford Motor Co. "New Ford H. Line of COE Trucks." Continental Hotel, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m.

METROPOLITAN

February 9 . . . George Kellis, Sinclair Refining Co. "Rocket Fuels." **Roger Smith** Hotel, Lexington Ave. and 47th St., Manhattan. Luncheon 12:00 Noon. $3.00 including tip.

February 16 . . . Norris E. Shoemaker, Cornell Aeronautical Laboratory. "Highway Safety." Henry Hudson Hotel, 57th St. and Ninth Ave., Manhattan. Meeting 7:45 p.m.

February 23 . . . John K. Roper, Grumman Aircraft Engineering Corp. "Fundamental Characteristics of Hydrofoils." **Bethpage State** Park, Bethpage, L. I., New York. Dinner 6:30 p.m. Meeting 7:45 p.m.

MID-CONTINENT

February 17 . . . A. H. Fries, executive staff engineer, Chrysler Corp. "The XM 410 Light Weight Truck." Hotel Cushing, Cushing, Okla. Dinner 6:00 p.m. Meeting 8:00 p.m. Special Feature: Social Hour 7:00 p.m.

MID-MICHIGAN

March 6 . . . Troy Ruttmann, president, Troy Ruttmann Enterprises. "Racing — Indianapolis to Go-Karts." General Motors Institute, Flint. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: "Red" Jones, Baseball Umpire.

MONTREAL

February 20 . . . Kelly Arrey, research engineer, Technical Research Branch, Canadian National Railways. "New Disc Brakes as Applied to Railway Equipment." Sheraton Mt. Royal Hotel, Peel & Burnside. Host — Canadian National Railways. Dinner 7:00 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA

February 11 . . . Gala Valentine Party. The Tahitian, Studio City. Dinner 7:00 p.m. American or Cantonese dinner. Dancing, Floor Show.

ROCKFORD-BELOIT

February 6 . . . Joe B. Snoy, C. E. Transmission Section, Twin Disc Clutch Co. "Why

— continued —

Section Meetings

— continued —

is a Transmission?" Wagon Wheel Lodge, Rockton. Dinner 6:45 p.m. Meeting 8:00 p.m. Coffee Speaker J. B. Schubeler, "Gold & Iron."

SOUTHERN NEW ENGLAND

February 6 . . . 1961 SAE President, Dr. A. Kucher, vice president, engine and research, Ford Motor Co. "Leva-car." American Bosch Division Cafeteria, Springfield, Mass. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: 25th Anniversary Celebration of Southern New England Section.

SOUTH TEXAS

February 26 . . . Carl Umland, Enjay Co. "Butyl Rubber." Petroleum Center Club, San Antonio. Dinner 7:00 p.m. Meeting 8:00 p.m.

TEXAS

February 10 . . . Leonard Raymond, chief automotive engineer — research, Socony Mobil Oil Co. "European Automotive Trends." Lucas B & B Restaurant, Oak Lawn Ave., Dallas. Social Hour 6:30 p.m. Dinner 7:00 p.m. Meeting 8:30 p.m.

WASHINGTON

February 21 . . . K. A. Austin, director of sales engineering for Gas Turbines and L. S. Votre, chief engineer of Amphibious Designs, Lycoming Division, AVCO Corp. "Hydro-Foil Design — Turbine-Driven Amphibians — The New Trend in Fast Assault Craft." Officers Mess, Naval Weapons Plant, Washington. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Feature: Color Movies.

METROPOLITAN SECTION

March 9, 1961

Henry Hudson Hotel, 57th St. & Ninth Ave.

T & M and PASSENGER CAR

"New Attitudes and Concepts in Motor Vehicles"
Ray J. Potter — *Ford Motor Company*
"30,000 Mile Project"

John Z. DeLorenn — *Pontiac*
"The Pontiac Tempest"

Dr. R. Burton Power — *Tung-Sol Electric, Inc.*
"Further Developments in Transistorized Ignition"

F & L and DIESEL

"Fuels for the Sixties"

W. D. Dukek — *Research Associate*
Products Research Division
Esso Research & Engineering Co.
"Supersonic and High Energy"

Earl J. Gay — *Consultant — Ethyl International*
"Distillates"

L. J. Test — *Atlantic Refining Company*
Gasolines"

AEROSPACE and AIR TRANSPORT

"Corporate and Short Range Jet Transport"
R. Bergeson — *Ford Motor Company*
"Need and Market"

A. B. Croshere — *Douglass Aircraft — Assistant Chief*
Advanced Design Section — Transport
Aircraft — Engineering Department

Paper by: E. F. Burton — *Vice President Engineering* and
A. B. Croshere

"Economics of Short Range Commercial Jet Transports"

To be announced — *Federal Aivation Administration*
"Problems of Airways with Commercial Jet Transports in Service"

SAE MEMBERS

WALLACE W. WITHEE has been named to the newly created post of senior assistant chief engineer at Convair (Astronautics) Division of General Dynamics Corp. As senior assistant chief engineer, Withee will direct engineering operations including design and test of the Atlas intercontinental ballistic missile and space programs. He was formerly assistant chief engineer of testing.

RAYMOND O. OYLER, director of sales for Bunting Brass & Bronze Co. has been elected vice-president. In this new capacity he will continue to direct the company's selling efforts.

JOHN R. PARKER has been elected vice-president of the A. O. Smith Corp.'s automotive and railroad products. Formerly he was director, sales and engineering, Automotive Division at A. O. Smith Corp.

E. L. LUDVIGSEN has been elected vice-president-administrative of Eaton Mfg. Co. In this capacity, he will have full responsibility over the Fuller, Unit Drop Forge, and the Shuler Axle Co. subsidiaries of Eaton Mfg. Co. A member of the board of directors of Eaton, he has been president of Fuller since 1940.

WILLIAM B. SHIMER, formerly with Chrysler Corp. has been appointed director of manufacturing services for Borg-Warner Corp. Formerly he was manager of industrial engineering for Chrysler Corp.'s Imperial Assembly Division.

RENE H. VANSTEENKISTE has joined Budd Co.'s Automotive Division as research and development engineer. He comes to Budd Co. from the advanced product study office of Ford Motor Co.

DONALD PICKLES has been appointed manufacturing and production engineering manager for Ford Motor Co.'s Metal Stamping Division. In the newly-created position, he will direct activities of a component in which the former production engineering, manufacturing engineering, material handling and work standards departments are consolidated.

GEORGE BERNARD has been appointed manager of the material forming and assembly department of Manufacturing Staff, succeeding **Pickles.** He served previously as manager of production for Lincoln, and manager of quality control for Lincoln-Mercury Division.

J. F. RANDALL has become manufacturing engineering manager of the Automotive Assembly Division at Ford. He was formerly director, manufacturing engine office.

Withee

Parker

Shimer

Oyler

Ludvigsen

Vansteenkiste

SAE FATHER AND SON

RICHARD GURSKI (right) is shown with his father, **JOSEPH GURSKI**, a member since 1945. The senior Gurski is manager, Chemical and Metallurgical Laboratory Service, Ford Motor Co. He is a member of the 1960 SAE Board of Directors and a member and past chairman of the SAE Nonferrous Metals Technical Commitee and of the SAE Iron and Steel Technical Committee. He has been a member of the Engineering Materials Activity Committee since 1953 and its meeting vice-chairman for two years. He has also been a member of the SAE Detroit Section Governing Board for two years.

Richard Gurski graduated from MIT with a B. S. in mechanical engineering in 1959. He is presently employed as a research assistant in MIT's Dynamic Analysis and Control Laboratory and is studying for his master's degree.

LAURENCE A. KEIM has been appointed manager of technical service — automotive sales, for Glass Division of Pittsburgh Plate Glass Co. Formerly he was technical representative of the company.

R. A. MAXWELL has become vice-president in charge of sales at Kelsey-Hayes Co. Formerly he was manager, equipment sales for B. F. Goodrich Tire Co.

WILLIAM J. BIRD has been appointed director — fleet sales for Chrysler Corp. Formerly he was assistant general manager of the Dodge Division, Chrysler Corp.

ANDREW J. HOLT has been made maintenance manager for Berman Service, Inc. He was formerly superintendent, equipment at Southern Pennsylvania Bus Co.

T. FINKELSTEIN has resigned from his professorship at the University of Wisconsin and shall commence new duties in industrial development work at Battelle Memorial Institute.

E. A. NIELSEN has been appointed chief — fluid systems section at The Martin Co. Formerly he was assistant chief engineer — design branch at Chrysler Corp.

CHARLES L. TUTT, JR. has been named to the newly created position of dean of engineering at General Motors Institute. He was formerly administrative chairman of the fifth-year and thesis programs.

LESLIE C. WOLCOTT has been appointed general manager of the Inland Mfg. Division of General Motors Corp. He was formerly director of engineering at GM's Packard Electric Division.

A. E. KIMBERLY has been named to the newly created position of chief engineer — vehicle reliability for Chrysler Corp.'s Engineering Division. He was chief engineer and director of products for the DeSoto Division, Chrysler Corp.

ROBERT L. KESSLER has been named general manufacturing manager at Buick. He was formerly works manager of the Delco-Remy Division of General Motors Corp.

MERRILL A. SCHEIL has been elected national secretary of the American Society for Metals. He was formerly national trustee of ASM.

JOHN D. CALHOUN, JR. has been appointed research engineer for Remington Arms Co., Inc. He was formerly test and development engineer for Chrysler Corp.

MYRON TYGAR, formerly technical representative for Industrial Products Division, Boeing Airplane Co., has become applications engineer, United Technology Corp.

WILLIAM E. WAGAR has become project engineer for Pratt & Whitney Aircraft Division, United Aircraft Corp. He was formerly senior engineer, Aviation Gas Turbine Division, Westinghouse Electric Corp.

EDWIN V. STEPHENS has been made senior design engineer — project head television equipment at Houston Fearless Corp. He was formerly senior design engineer — project engineer, ground support equipment for Horkey-Moore Associates.

MAX H. SCHACHNER has become executive engineer for Keco Industries, Inc. He was formerly manager, Coldmobile Division, Union Asbestos & Rubber Co.

KENNETH F. PITMAN has been appointed superintendent — Technical Division (Japan), Lockheed Aircraft International. He was formerly assistant project engineer — F-104 Division, Lockheed Aircraft Corp.

E. M. DOUGLAS has been named vice-president of manufacturing for Dana Corp. R. R. Burkhalter has been named Technical Director of Dana's newly formed International Division and P. J. Mazziotti was appointed Director of Engineering.

Bender

Bourdon

Heller

R. O. BENDER has resigned his position as assistant director, petroleum laboratory at E. I. duPont de Nemours & Co., Inc. to enter the ministry. This will be effective February 28, 1961.

He expects to attend the Philadelphia Theological Seminary of the Lutheran Church.

Bender was a member of SAE Steering Committee.

STANLEY J. BOURDON was named Detroit office manager for the Original Equipment Division of the Muskegon Piston Ring Co. He was formerly sales engineer of the company.

RAYMOND H. HELLER has been appointed general manager of Robertshaw-Fulton Controls Co.'s Aeronautical and Instrument Division. He was formerly director of field engineering and sales for the division.

ARLISS J. GORBY, formerly supervisor of warranty claim processing at Cummins Engine Co., has become junior engineer, Sales Development Division, Aluminum Co. of America.

WILBUR T. HOOVEN, III, formerly sales engineer for Dana Corp., has become engineer — industrial sales at General Electric Co.

THEODORE R. DIEGEL, formerly manager of manufacturing and engineering for Cleveland Engine Plants of Ford Motor Co., has been appointed manager, machining process department at Ford.

BERNARD A. CHAPMAN, executive vice-president and general manager of Appliance Division, American Motors Corp., has become executive vice-president responsible for all automotive and appliance manufacturing, engineering, styling and procurement.

He is also a director of the corporation.

RAYMOND F. WINCH has become project analyst for the Commercial Development Division of Sun Oil Co.'s research and engineering department. He was formerly on the staff of the assistant director for motor products in research and development.

PETER L. PAULL, vice-president of Texaco Development Corp., has been awarded as copatentee with C. F. Teichman of United States Letters Patent No. 2,954,290 covering improvements in process for recovering metal values from gold and silver ores.

M. G. BEKKER, chief, Land Locomotion Laboratory, Ordnance Tank Automotive Command, Detroit, is the author of a new volume on research and development in terramechanics: "Off-the-Road Locomotion." This book takes its place with the author's "Theory of Land Locomotion" as the first to offer systematic research on the vehicle as a unit in relation to environmental terrains. Bekker shows how predictions can be made of vehicle performance and design parameters. He discusses soil and snow mechanics, tracks, wheels, and tires, as well as general factors having to do with vehicles at asumed optimum performance. He also describes important developments occurring in industry and education, offering a strong claim that automotive research can remain vital only if it is broadened to include theoretical as well as design analysis. Pub. by Univ. of Mich. Press. $10. 220 pp., inc. 106 charts, diagrams, and photographs.

J. RAYMOND MOHLIE has been appointed vice-president and general manager at Engineering Castings, Inc. He was formerly vice-president of the Rich Mfg. Corp., Battle Creek, Mich.

JOHN M. O'BRIEN has become assistant senior design engineer for Ryan Aeronautical Co. Formerly he was assistant chief engineer at Rosan, Inc.

CARL F. JOSEPH, technical director of Central Foundry Division, General Motors Corp., retired December 1, 1960 after over 43 years of service with General Motors and the division.

Fred Zollner

FRED ZOLLNER, president of Zollner Corp., Fort Wayne, Ind. on December 15, 1960 received an honorary degree of Doctor of Engineering presented by Tri-State College of Angola, Ind. at commencement ceremonies.

JAMES KNOWLES, formerly executive assistant, to vice-president manufacturing, Automotive Assembly Division of Ford Motor Co., has been appointed quality control manager of the division.

L. R. BAKER, director, Chrysler Institute of Engineering, and **HOLLISTER MOORE**, secretary to the SAE Sections Board have been named members of the SAE Steering Committee of the Relations with Industry Division of the American Society of Engineering Education. Chairman of the Steering Committee is Cornelius Wandmacher, associate dean, College of Engineering, University of Cincinnati.

GEORGE R. FUSNER has joined the Knolls Atomic Power Laboratory at General Electric Co. as supervising engineer in the submarine Advanced Reactor project. He was formerly supervisor, proposition and contract unit at General Electric Co.

WALTER E. SHIVELY, "dean of tire engineering" in the rubber industry, has retired after 45 years with Goodyear Tire & Rubber Co. Shively was Goodyear's manager of tire engineering development since 1930.

DR. RALPH A. SCHAEFER has been appointed director of research of Electric Storage Battery Co. Formerly he was director of engineering and research of Bunting Brass & Bronze Co.

JAMES J. WELKER has been appointed executive vice-president at Trailmobile, Inc.

SAE NATIONAL MEETINGS

- March 13–17

  National Automobile Week (National Automobile and Production Meetings), The Sheraton-Cadillac, Detroit, Michigan.

- April 4–7

  National Aeronautic Meeting (including production forum and Engineering display), Hotel Commodore, New York, N. Y.

- June 4–9

  Summer Meeting, Chase-Park Plaza, St. Louis, Mo.

- August 14–17

  National West Coast Meeting, Sheraton Hotel, Portland, Ore.

- September 11–15

  National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display)

  National Transportation Meeting

  National Powerplant Meeting
  . . . Milwaukee Auditorium, Milwaukee, Wis.

- October 9–13

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- November 9–10

  National Fuels and Lubricants Meeting, Shamrock Hotel, Houston, Texas.

SAE LETTERS FROM READERS

From:
Bengt F. Friberg
Consulting Engineer
915 Olive St.
Saint Louis 1, Mo.

Dear Editor:

In connection with the challenge of urban transportation, I wish to ask SAE's cooperation on a very small matter, which is, nevertheless, of substantial effect.

Urban transportation should not be called "mass transportation." Much of our unnecessary commuting traffic today consists of persons driving to work for the mere sake of not being considered part of the "mass."

In connection with the express transportation we propose the term is incorrect.

From:
John E. Morton (J '60)
1312 Porter (Apt. 54)
Dearborn 8, Michigan

Dear Editor:

I would like to congratulate you on your fine editorial on page 23 of the December, 1960 issue. What you have said about the "time" element in relationship to personal responsibilities is very true.

It is my personal opinion that our nation is in grave danger of Communist domination in the next 15 to 20 years. I believe the answer to this problem lies in the people of our nation realizing their personal responsibilities, and then finding the time to carry them out. Personal responsibility leads to national responsibility.

If we are to be a leading nation in the world, then we must demonstrate a high degree of responsibility. This can only happen when the majority of our population realizes and accepts its moral responsibilities.

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

SAE Helps Military Use Industry-Made Standards

U. S. Government has been authorized to duplicate SAE standards for immediate Government use as an added SAE assistance to implementation of an August, 1960 Department of Defense directive which covers recognition of industry-generated standards by the military services.

SAE has also offered to supply DoD officials with small quantities of SAE-printed SAE Standards without cost; and to make available to the Government larger quantities at special prices.

The new directive (DoD No. 4120.8) prescribes a uniform DoD policy for getting recognition for industry-generated standards — which heretofore have been recognized by a variety of procedures. The new policy seems likely to bring recognition to a number of SAE Standards in addition to the many already Government-approved.

The procedures center around a requirement that each industry standard seeking approval shall have an internal sponsor in the Department of Defense. This sponsor will coordinate the industry document throughout DoD activities.

The SAE offer to facilitate availability of copies of its standards stems from DoD indications that lack of such availability might, in some cases, be a hindrance to prompt Government use.

The military want to use industry material, equipment, and specifications wherever possible. With the largest single stockpile of on-the-shelf standards of any technical organization, SAE bids fair to have its standards play a constantly increasing role.

Technishorts . . .

E-25 SELECTS CHAIRMAN EMERITUS — Virgil E. Newman was made chairman emeritus by SAE Committee E-25, Engine and Propeller Standard Utility Parts, at a meeting last fall. His diligence as a committee member and, in recent years, as chairman and vice-chairman were cited by fellow members prior to his selection. Newman, who retired in 1960 from Wright Air Development Center, began his E-25 association in 1948.

STANDARD MARKINGS FOR LIGHT DEVICES — A series of standard markings, presented as a new SAE Recommended Practice, will enable manufacturers and suppliers to mark their products so that the SAE Lighting Standard or Standards to which a device is designed to conform will be indicated. Titled Lighting Identification Code, the report will appear in the 1961 edition of TR 34 as well as in the 1962 SAE Handbook.

F. C. KOCH, Detroit Arsenal, has been elected chairman of the Engine Committee's Filter Test Methods Subcommittee. He succeeds **R. J. POCOCK** whose leadership brought the Lube Oil Filter Performance Test to fruition in 1958. Soon after, the Subcommittee, with Koch as secretary, began work on the proposed Fuel Filter Test Methods which were previewed at two sessions of the SAE International Congress in Detroit last month.

H. M. KENNEDY, Superior Equipment Co., is the new chairman of the Construction and Industrial Machinery Technical Committee's Subcommittee XI — Tractor Mounted Side Booms. He succeeds R. J. Schroeder, Allis-Chalmers Mfg. Co. Currently, the Subcommittee is developing a recommended performance test procedure for track and wheel type tractor-mounted side booms.

1961 SAE Technical Board

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18 Engineers Receive SAE Certificates of Appreciation

Bassett

Dalrymple

Finch

Fisher

1960 SAE Technical Board Chairman A. A. Kucher cited unique contributions made by 18 engineers to SAE Technical Committees during a special luncheon held January 12 at Detroit's Cobo Hall. There to congratulate recipients was 1960 SAE President Harry Chesebrough who distributed the Certificates of Appreciation while Dr. Kucher pointed out the following contributions to the work of SAE standardization groups.

J. V. BASSETT has rendered an immeasurable service to the Brake Committee during his 25-year affiliation. A key industry member of the war-time Bureau of Public Roads Brake Project, he has also served as chairman of Subcommittee I on Brake Effectiveness and of a special friction testing group. Among the SAE reports on which Bassett has worked with particular diligence are *Brake Linings* and *Brake Lining Quality Control Test Procedure*.

M. W. DALRYMPLE, during his chairmanship of the Iron and Steel Technical Committee's Division VII on Carbon Steels, did an outstanding job of leading the Division in its expansion of SAE's carbon steel list, including specifications for leaded steels. His diplomatic leadership has been particularly valuable at ISTC meetings.

PROF. D. M. FINCH has made major contributions to all the activities of the SAE Lighting Committee. Of special note is his service to the Subcommittees on Headlamp Beam Switching Devices and Automotive Flashers. Prof. Finch has also served SAE as a representative on the U. S. National Committee of the International Commission on Illumination.

HAROLD FISHER has one of the longest service records on the Automotive Drafting Standards Committee, serving as a member since its inception in 1948 and as vice chairman since 1956. He has contributed to this group's vitality by sponsoring projects on metal stampings and rubber. Fisher is also a charter member of the Aeronautical-Automotive Drawing Standards Committee, and is chairman of the SAE Handbook Illustration Subcommittee.

GEORGE F. KAPPELT has aided the Aeronautical Material Specification cause by 12 years of participation in SAE Aerospace Materials Division work. Since 1957, he has been chairman of the AMS Nonferrous Materials Commodity Committee. As a member of the Editorial Consultants Committee, he helped gain industry/government acceptance of AMSs which are distributed by SAE at an annual rate of 700,000.

C. J. LIVINGSTONE has helped resolve divergent industry opinions of

Kappelt

Livingstone

Manning

McCain

Messinger

those concerned with performance characteristics of petroleum and synthetic based central system hydraulic fluids. Through skillful coordination between the Fuels and Lubricants Technical Committee's Subcommittee on Power Assist Fluids and a Subcommittee of the Nonmetallic Materials Committee, publication of the new SAE Recommended Practice, Central System Fluids, was made possible.

For over 10 years, **DONALD E. MANNING** has improved the editorial and technical content of SAE Aeronautical Material Specifications. As chairman of the AMS Editorial Consultants Committee since 1958, he and fellow members review approximately 175 documents each year.

G. L. McCAIN played a vital part in integrating three standards into the Involute Splines, Serrations, and Inspection Standard which now occupies 80 pages of the SAE Handbook. He has worked on the Parts and Fittings Committee, Engineering Drawing Standards Committee, as well as with many other SAE groups.

The current chairman and a 15-year member of Committee A-9, Aerospace Environment Systems, **B. L. MESSINGER** has contributed to the solution of many standardization problems related to aircraft heating, ventilation, and pressurization. Early in 1960, he became chairman of the A-9 Subcommittee which produced the SAE Aerospace Applied Thermodynamics Manual, a 1000-page, one-stop reference for designers of fluid systems used in airborne and space vehicles.

Equipped with a knowledge of the need for information on how to design vibration isolation systems into aircraft, **DR. C. T. MOLLOY**, with SAE Aerospace Council support, organized Committee G-5, Shock and Vibration, in 1955. Since then, great progress has been made toward producing a comprehensive Shock and Vibration Manual which will tell designers what basic information is needed to isolate vibration, if an isolation system is needed, how to use performance equations provided in the Manual, and how to execute and check designs.

V. E. NEWMAN has served Committee E-25, Engine and Propeller Standard Utility Parts, as chairman from 1958–1960, as vice-chairman from 1956–1958, and as a member since 1946. Noteworthy has been his work on fatigue testing of exotic materials. He was also instrumental in expanding E-25 work into the field of ram-jet and solid and liquid non-breathing propulsion systems.

C. F. NIXON, a current member of the General Materials Council, has been a member of the Nonferrous Metals Committee for 17 years. Serving as chairman and vice chairman for a combined total of 5 years, he was also chairman of the Cast Aluminum Alloy Subcommittee for 11 years. During this time, extensive revision were made to a number of nonferrous standards.

A major contributor to accomplishments of the Lighting Committee, **G. W. ONKSEN** has served on nearly all of its subcommittees. As chairman of the Headlamp Testing Machines Subcommittee, he played a key part in developing the SAE Recommended Practice covering the recently developed mechanical headlamp aimer. During his chairmanship of the Reflex Reflector Subcommittee, work on a new standard for emergency reflector warning devices was initiated.

ISTC Division on Residual Stresses would not be the authoritative group it is today if **DR. E. S. ROWLAND** had not become its first chairman in 1953. His leadership has brought to light much hitherto unavailable information on residual stresses. In 1959, Dr. Rowland became chairman of the ISTC which he led over many difficult problems. He is currently a member of the General Materials Council.

C. F. SCHAENING's fair handling of work involving user/supplier interests has won the respect of fellow members of the SAE Tube, Pipe, Hose, and Lubrication Fittings Committee. Noteworthy has been his approach to standardization problems from the standpoint of economies it affords industry.

A former chairman of Committee E-21, Design and General Standards for Aerospace Propulsion Systems, **D. J. SEIDEL** has sponsored many important projects. Among them was the preparation of documents on high-temperature bolting. Other services include membership on Committees E-25; A-6, Aerospace Hydraulic and Pneumatic Systems and Equipment; G-3, Aerospace Fittings and Flexible Hose Assemblies; and G-4, Elastic Seals.

R. K. SUPER has served with distinction as a member of the Brake Committee since it was organized in 1946. In addition to heading the Brake Steering Committee, he has led Subcommittee III which develop the SAE Brake Dynamometer Test Code. Super is currently chairman of Subcommittee VII on Road Test Procedure.

DR. LLOYD WITHROW has earned a coveted reputation by spurring action of the Fuels and Lubricants Technical Committee, especially on SAE engine lubricant specifications. A current member of three Subcommittees (Motor Fuels, Power Assist Fluids, and Engine Lubricants), Dr. Withrow is noted for promoting harmony among his associates. He was recently appointed to represent SAE on ASTM Sectional Committee Z-11, Petroleum Products.

Molloy

Newman

Nixon

Onksen

Rowland

Schaening

Seidel

Super

Withrow

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Continued on next page

SAE Student Branch Officers
1960–1961

— continued —

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THE SOCIETY OF AUTOMOTIVE ENGINEERS, INC.

annual report 1960

SAE ENTERS A NEW ERA

When the 1956 Council created the Planning for Progress Committee, little did these men dream of the explosion of constructive activity and accomplishment that would be generated so early after completion of the project. SAE's reorganized structure, which officially came into being in January, 1960, has brought with it a greatly expanded program of improved and extended services for SAE members. Even greater potentials are in the offing.

The PFP planners already know that their objective is being realized. In fact, the fuse was a lot shorter than we thought, and we're in about the same position as the nuclear physicist trying to harness a tremendous release of energy. The details of the Society's work in 1960, highlighted in this report, give some indication of the channels into which this energy release has been directed.

When the Planning for Progress Committee first went into action, it set its sights on:

- PARTICIPATION of more members in the work of the Society.
- FLEXIBILITY of our structure to accommodate itself to changing and growing technical information needs of our members.
- CONTINUITY of member leadership and member participation in all of the groups performing the work of the Society.

From what you will see in the pages that follow, it will be apparent that these three aims already have been realized in very measurable quantities . . . and at a much faster rate than anyone ever dared hope. The future holds nothing but more of the same for the Society. It gives promise of making available to our members improved and expanded services so that they may better meet the growing pressures and demands placed on them as engineers, researchers, and scientists.

I wish to express my sincere appreciation to the hundreds of SAE committees and the thousands of members who have actively participated in the Society's work this past year. The SAE record of accomplishment is a tribute to their selfless giving of their special talents and abilities, and their willingness to share with others their knowledge and technical competence.

My special thanks to the men who chairmanned the committees reporting directly to the Board of Directors and who are shown on these pages. Their leadership in their respective areas made the work of the Board of Directors most pleasant and constructive.

It is a pleasure and a thrill to have been on the scene as SAE President this year and to see our plans come to fruition so rapidly and successfully.

Harry E. Chesbrough

The September 20th Board of Directors' Meeting brought together the 1960 Directors as well as those nominated to serve in 1961.

After having served as SAE Secretary and General Manager for thirty years, John A. C. Warner (left) resigned and was appointed Advisory Consultant. Joseph Gilbert (right) was appointed as of July 1st to succeed Warner as the Society's third Secretary and General Manager at the Board of Directors' Meeting on June 10, 1960, presided over by President Chesebrough (center).

H. F. BARR
Chairman, Engineering Activity Board

W. F. FORD
Chairman
Sections Board

A. A. KUCHER
Chairman
Technical Board

O. A. BROUER
Chairman
Constitution Committee

A. T. COLWELL
Chairman
Finance Committee

W. J. LUX
Chairman
Membership Committee

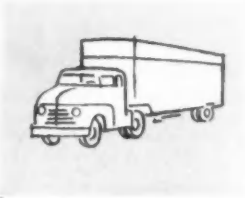
VINCENT AYRES
Chairman, Membership Grading Committee

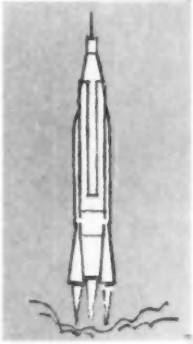
T. M. DUNN
Chairman
Placement Committee

T. L. SWANSEN
Chairman
Publication Committee

J. G. MOXEY, JR.
Chairman
Public Relations Committee

S·A·E
1960





IMPROVED TECHNICAL COVERAGE THROUGH ACTIVITY AREA EXPANSION

"To develop, collect, and distribute technical information of value to members of the Society in the areas of the Society's engineering interests" is the objective of the Engineering Activity Board. One of the first actions of EAB was to establish three new Activity Committees that concern themselves with: (1) the use of computing equipment for application to automotive engineering problems, (2) power generation from nuclear energy for vehicle propulsion, effects of high-energy radiation on materials, and application of nuclear radiation to automotive engineering, and (3) scientific discoveries, developments, and transition therefrom to automotive engineering applications.

During the year, three other major changes occurred in the Activity Committee structure: the airframe group in changing its name to Aerospacecraft Activity redefined its scope to cover the design, development, and performance of aerospace vehicles and missiles, including their ground support systems and components except powerplants. The committee concerned with aeronautic propulsion adopted the name Aerospace Powerplant Activity and outlined its area to be the design, development, and performance of propulsion and power generating systems and their components and auxiliaries for aerospace vehicles and missiles. The name Powerplant Activity was adopted by the group that had previously concentrated on diesel engines and the area of interest was broadened to cover the design, development, and performance of all powerplants except those specifically designed for aerospace vehicles, passenger cars, trucks, or buses.

To supplement the extensive overseas participation in the 1961 SAE International Congress of Automotive Engineering, steps have been taken to assure a continuing interchange with our friends abroad. An International Information Committee through "overseas" members will assist in obtaining information requested by Activity Committees and suggest possible authors. The "overseas" members will also report on topics and trends in their area.

The information development groups have disseminated, at the eleven SAE National Meetings and through the Society's publications, more engineering information than ever before. The 440 National Meeting papers represent a 20.5 per cent growth during the year and were presented at 219 sessions, 24 per cent more than 1959. Program planning committees advise that a higher level of quality is being realized due to more careful planning and the opportunity of being more selective. Two committees report that it was possible to schedule only one-third of the papers offered; therefore, the committees are looking toward the new publication outlets of the Society as another major means of distributing engineering information. To assist in the development of information of constantly higher quality, the Publications Advisory Committee of EAB has prepared guideposts on, "How to Get the Best SAE Papers."

Since an increasingly large number of nonmembers have been attending SAE National Meetings, the EAB developed a new schedule of guest registration fees. The EAB points out that the new $3 daily nonmember registration permits guests to select those portions of the program which are of interest and register only on the appropriate days. EAB members feel that many nonmembers will take advantage of the new registration fee policy, increasing nonmember exposure to SAE programs and enhancing the prospects for membership growth.

NEW REGISTRATION FEE POLICY ENCOURAGES NONMEMBER PARTICIPATION

TECHNICAL INFORMATION THROUGH VISUAL DISPLAYS

Engineering Displays held in conjunction with National Meetings have distributed engineering information visually on a larger scale than in previous years. Exhibitors have reviewed technical session subjects and have developed their displays to complement the programs.

At the Annual Meeting, where the Society's family of related technical interests are brought together, 75 exhibits of the latest products, manufacturing methods, processes, and techniques filled the enlarged display.

Since both of the Aeronautic Meetings include Production Forums, the Engineering Displays, using 162 booths, provided exhibits covering welding and brazing of ultra-high-strength and high-temperature materials and metal removal processes along with displays of special equipment for ground support, guidance systems, turbine developments, and auxiliary power units.

The Farm Construction and Industrial Machinery Meeting Engineering Display continued to grow. Seventy-eight exhibitors using 117 booths graphically illustrated new powerplants, power take-off equipment, and other products for off-highway vehicles.

The Display Committee of EAB, recognizing that the 500-booth 1961 SAE International Exposition of Automotive Engineering will create new problems, has developed an objective for and rules covering SAE Engineering Displays. "Exhibits should parallel and complement the technical program of the particular meeting where they are held. . . . Booths should be manned by technical specialists qualified to discuss engineering details of their products and programs. . . . The use of exhibits for direct sales of any manner are prohibited" are among the established guideposts.

OBJECTIVES FOR SAE ENGINEERING DISPLAYS DEFINED

S·A·E 1960

PUBLICATION FACILITIES EXPANSION APPROVED IN 1960

NEW FACILITIES
FOR PUBLISHING FULL-LENGTH
TECHNICAL MATERIAL

SAE facilities for publication of full-length papers and other technical material have been greatly expanded, as a result of Publication Committee studies begun immediately following completion of Planning for Progress several years ago.

These studies came to fruition in a program for expansion of SAE's General Publication facilities approved by the SAE Board of Directors in September, 1960.

The new facilities provide for publication of ALL full-length material developed and approved for publication by SAE Activity Committees, SAE Technical Committees, or other agencies of the Society. The entire expanded program will be implemented on the break-even basis required by previous Board of Directors' instructions to the Publication Committee.

Summarized, the expanded program consists of:

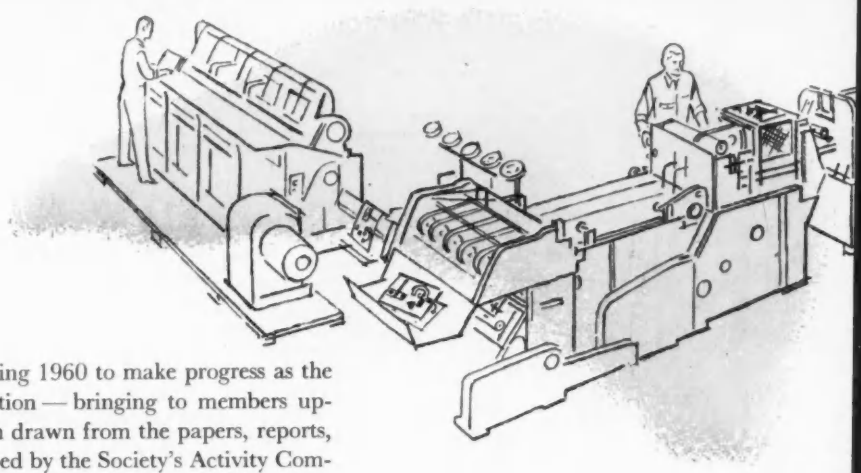
a) A new, edited Preprint—approximately the same in format and price (75¢) as the Preprint with which the Publication Committee made its experiments at meetings late in 1959 and early in 1960.

b) Continuation and improvement of SAE TRANSACTIONS as a key element in the expanded program . . . and the pricing of this publication at $6 (starting with the 1962 issue) to make it come closer to being self-supporting.

c) *Addition* of TWO NEW TYPES of publications — both devoted exclusively to publication of full-length technical papers, Activity Committee reports, or other SAE-sponsored presentations. The two new types of publications to be designated as:

TECHNICAL PROGRESS SERIES — to be symposia of papers or reports on a given subject . . . likely to be of reference value for *two or three* years . . . and to be reproductions of the new Preprint format, bound in *flexible* covers.

ADVANCES IN ENGINEERING SERIES — also to be symposia of papers or reports on a single subject . . . but likely to be of reference value for more than *five* years . . . and to be reproductions of the regular TRANSACTIONS format, bound in *hard* covers.



SAE JOURNAL continued during 1960 to make progress as the Society's monthly technical publication — bringing to members up-to-date articles based on information drawn from the papers, reports, and other technical material developed by the Society's Activity Committees and Technical Committees. As the official organ of the Society, the Journal also continues to keep members informed of Society actions and activities; and of news of its members' activities.

Many specific improvements have been made in SAE Journal as the result of the Eastman Editorial Research data which have been made available steadily for over three years. The cover format has been revised once and is in process of a second revision; the table of contents has been repositioned and made easier to use; handling of meetings stories has been modified; popular "departments" like CHIPS have been introduced; and typographical presentation and headlines have been made more interesting.

SAE Journal readers average about two hours on each issue, Eastman Research data indicate . . . an average which is higher than the composite of Eastman-research publications.

EASTMAN SPARKS MORE SAE JOURNAL IMPROVEMENTS

But more fundamental opportunities for betterment are revealing themselves, as cumulative results of the reader research become available. Editors are getting ever-better data upon which to base their judgments about "balance" of editorial material. Particularly is the guidance helpful as regards ground-vehicle and aerospace-vehicle interests. It is agreed editorially that the major long-term, continuing problem is:

> "To satisfy within the limits of a single Society or monthly magazine the technical information needs of so wide a variety of technical interests. And outstanding within this broad problem is that of satisfying both ground and aerospace interests."

Publication Committee analysis indicates that SAE Journal is doing well in these respects. Evidence continues to grow that every feature article in SAE Journal is read — and that the more popular ones are interesting to over half of the members.

Special effort will be made during the next twelve months further to improve the value as well as the interest of SAE Journal articles. The "quality papers" program currently being stimulated under Engineering Activity Board auspices is providing the sound basis upon which this value-improvement can be built.

PLACEMENT SERVICE MOVES WITH THE SOCIETY

The many discussions leading to the recent reorganization of SAE pointed up more clearly than ever that the Enrolled Student was the future backbone of the SAE. Following up on this, the Placement Service is catering to the Students more than ever before. Again this year their job requirements have appeared in the SAE Journal, but also being planned is a "special" for those Seniors who have just enrolled and who, therefore, missed the Journal listing.

In serving regular members, bulletins continue to carry many more position openings than there are applicants.

Of the total membership of 24,000 only 77 are listed in Men Available. An additional 400 receive the Positions Available Bulletin.

FINANCIAL SITUATION

G. A. DELANEY
Treasurer

Over the past two years, a formula was developed by the Finance Committee which aimed at providing adequate means for financing the already greater activity and for taking advantage of the tremendous potential envisaged by the reorganization of the Society's structure.

The most important financial element was the change in the dues schedule, which becomes effective with the 1960–61 fiscal year. Payments of members' dues under the new dues schedule are running in line with budget anticipations. It is anticipated that member service operations, which were in the red in the 1959–60 fiscal year, will produce a black figure in the 1960–61 fiscal year as a result of the new dues schedule.

The Society's reserves are progressing in a satisfactory manner and with a favorable balance of income and outgo. The financial soundness of the Society seems assured for the immediate future. The details of the 1959–60 figures are set forth on other pages of this report.

HASKINS & SELLS

CERTIFIED PUBLIC ACCOUNTANTS

TWO BROADWAY
NEW YORK 4

Society of Automotive Engineers, Inc.:

We have examined the balance sheet of the Society of Automotive Engineers, Inc. as of September 30, 1960 and the related statement of income and expenses, and general fund, for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statement of income and expenses, and general fund, present fairly the financial position of the Society at September 30, 1960 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

November 9, 1960.

Haskins & Sells

BALANCE SHEET

September 30, 1960

ASSETS		
GENERAL CASH		$ 164,317
RESTRICTED FUNDS:		
Cash (Including $13,870 in Savings Banks)	$ 15,139	
Securities (Market Value $16,160)	17,915	33,054
RECEIVABLES (Net of Reserve of $1,000)		33,822
INVESTMENT FUNDS:		
Investments at Cost	*1,453,393	
Cash	9,895	
Accrued Interest	5,158	1,468,446
INVENTORIES (Principally at Cost)		55,566
FURNITURE & FIXTURES (Arbitrary Value)		1,000
PREPAID EXPENSES AND DEFERRED CHARGES		106,083
TOTAL		$1,862,288

LIABILITIES		
ACCOUNTS PAYABLE		$ 97,365
SECTION DUES PAYABLE		17,995
DEFERRED INCOME:		
Members' Dues and Journal Subscriptions	$ 353,889	
Journal Subscriptions — Nonmembers	10,634	
Dinner and Displays	146,712	
Cooperative Engineering Program	65,676	
Transactions, Handbook, etc.	33,340	610,251
RESTRICTED FUNDS		33,054
GENERAL FUND		1,103,623
TOTAL		$1,862,288

* MARKET VALUES AT SEPTEMBER 30, 1960	MARKET	COST
US Government Bonds	$ 103,497	$ 119,311
US Government Discount Bills	297,630	297,332
Corporate Bonds	346,038	363,750
Common Stocks	1,141,835	673,000
TOTAL	$1,889,000	$1,453,393

S·A·E 1960

STATEMENT OF INCOME AND

For Year Ended September 30, 1960

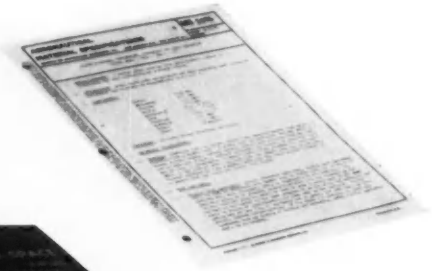
INCOME		
MEMBERSHIP		
Dues and Journal Subscriptions	$535,275	
Initiation Fees	31,718	
Emblem Sales	1,652	$ 568,645
PUBLICATIONS		
Journal Sales	27,592	
Journal Advertising	531,098	
Handbook Sales	84,559	
Handbook Advertising	19,256	
Transactions Sales	20,280	
Special Publications Sales	111,436	794,221
NATIONAL MEETINGS		
Guest Registration Fees	16,939	
Dinners and Luncheons	33,337	
Displays	134,585	
Summer Meeting Registration Fees	2,210	187,071
COOPERATIVE ENGINEERING PROGRAM		
Aeronautical Publications Sales	110,015	
Industry Contributions	357,992	
Transferred to Deferred Income	(49,106)	418,901
INVESTMENTS		
Interest	17,674	
Dividends	22,051	39,725
TOTAL INCOME		$2,008,563
EXPENSES		
SECTIONS AND MEMBERSHIP		
Sections Department	$ 20,399	
Section Dues and Appropriations	86,860	
Membership and Student Departments	76,009	
Miscellaneous Membership Expenses	1,367	$ 184,635
WESTERN BRANCH OFFICE		34,664
PUBLICATIONS		
Journal Production and Mailing — Editorial	218,347	
Roster (13th Journal Issue)	38,939	
Journal Advertising	272,276	
Handbook Production and Mailing	61,964	
Handbook Advertising	5,307	
Transactions Production and Mailing	42,552	
Special Publications	78,759	
Purchase Discounts	(1,372)	716,772
FORWARD		$ 936,071

EXPENSES, AND GENERAL FUND

TOTAL INCOME — (FORWARD)		$2,008,563
EXPENSES — (FORWARD)		936,071
NATIONAL MEETINGS OPERATIONS		
Meetings Operations Department	27,667	
Meetings	33,595	
Dinners and Luncheons	37,369	
Displays	37,661	136,292
ENGINEERING ACTIVITY		
Salaries and Expenses	71,717	
Meetings Programs	26,304	
Activity Committees	8,945	
Awards	253	107,219
COOPERATIVE ENGINEERING PROGRAM		
Aeronautical Publications	62,732	
Technical Committees	193,426	
Handbook Editorial Salaries and Expense	12,572	
CRC Appropriation	30,000	
Solicitation of Industry Contributions	14,078	312,808
GENERAL MANAGEMENT AND ADMINISTRATIVE		
General Management	111,654	
Board of Directors	12,359	
Administrative	55,741	
Service Departments	174,520	
Furniture and Fixtures	12,479	
Rent and Light	80,465	
Retirement Plan and Other Employee Benefits	57,713	
Miscellaneous	2,692	507,623
TOTAL EXPENSES		$2,000,013
EXCESS OF INCOME OVER EXPENSES (Before Net Loss on Sale of Investments)		8,550
NET LOSS ON SALE OF INVESTMENTS		(3,545)
EXCESS OF INCOME OVER EXPENSES		5,005
GENERAL FUND, SEPTEMBER 30, 1959	1,115,188	
LESS TRANSFER TO DEFERRED INCOME — COOPERATE ENGINEERING PROGRAM (Applicable to Prior Years)	16,570	1,098,618
GENERAL FUND, SEPTEMBER 30, 1960		$1,103,623

Proration of General Management and Administrative Expenses

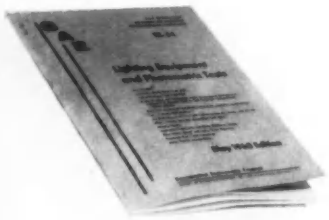
To	%	Expense Proration	Direct Expenses	Total
Sections and Membership	12.4	$ 62,945	$ 184,635	$ 247,580
Western Branch Office	2.3	11,676	34,664	46,340
Publications	48.0	243,659	716,772	960,431
National Meetings Operations	9.2	46,701	136,292	182,993
Engineering Activity	7.2	36,549	107,219	143,768
Cooperative Engineering Program	20.9	106,093	312,808	418,901
TOTALS	100.0%	$507,623	$1,492,390	$2,000,013



CEP BROADENS SERVICES EMPHASIZING MAN VERSUS MACHINE

During 1960, the Society's Cooperative Engineering Program reached a new level of service to industry with the approval and release of 378 technical reports and standards. Broad results are evidenced in the 1961 SAE Handbook which contains 24 new reports, 68 reports technically revised, 25 reports editorially revised, and 18 reports reviewed and reaffirmed. Technical achievements have been scored by SAE groups in mating vehicles to man's needs and limitations.

1960 marks the 20th year of teamwork between the Aerospace Industries Association and the SAE in a cooperative engineering effort. The Aerospace Council, in noting this occasion, pointed out that two decades of progress resulted in: (1) publication of 1,326 industry aerospace specifications, standards, and reports (over 13,500,000 copies of these documents have been distributed to industry), (2) release of more than 1,050 specific technical comments and recommendations to cognizant Government agencies, (3) development and preparation of 415 propulsion Military Standards published by the Defense Department.

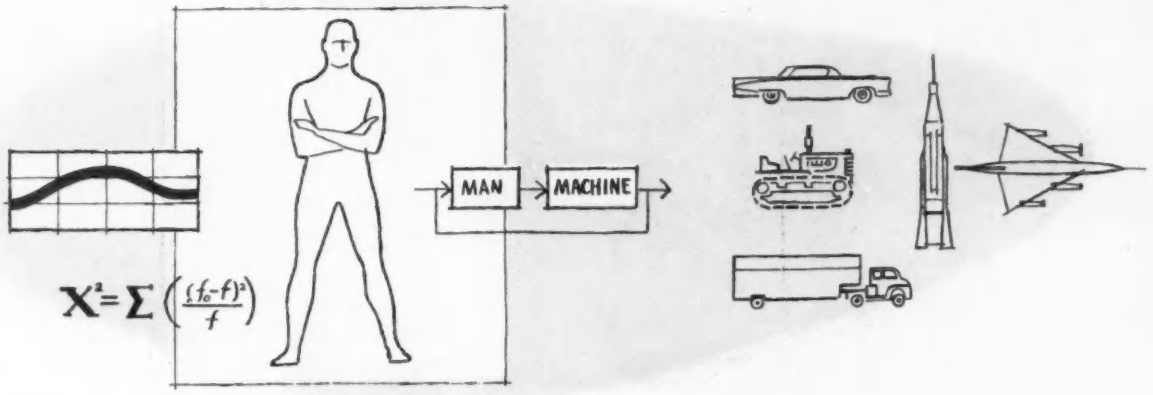


Two major factors account for CEP's expanded service: namely, the streamlining of SAE Technical Committee report coordination and approval practices, and a recent policy to review and update all currently published reports on a periodic basis.

SAE Technical Committees are embarking on problems of physical tolerances, human reaction time, eye movement studies, and human resistance to shock and vibration aimed at adapting equipment to man's physiological and psychological limitations.

The Construction and Industrial Machinery Technical Committee is expanding its activities into the field of human engineering. Its group on Winterization has been broadened to encompass operation of equipment in other types of environment, such as the tropics and desert areas. The subject of human engineering and the role it plays in the design of earthmoving equipment is to be studied. This activity is aimed at determining man-machine relationships and how these relationships can be used in developing more efficient equipment.

The Riding Comfort Research Committee is continuing its cooperative work on developing a means of measuring driver comfort in truck cabs. One aspect of the current investigation is the evaluation of a way to relate vibration experienced by a



driver to a calibrated noise level. This investigation is being conducted in different truck cabs under varying type road conditions.

The Motor Vehicle Seat Belt Committee has initiated a project to determine the feasibility of standard tests for seat belts for small children. Preliminary reports indicate a need for more information on the physiology of the typical child.

HUMAN FACTORS OF PASSENGER CAR SEATING AND REAR VISION STUDIED

Under the Body Engineering Committee, the Glazing Subcommittee is engaged in a detailed study of rear vision aspects of operating a vehicle, i.e., what are the rear vision visibility areas required by a typical passenger car driver? The Seating Subcommittee has completed work on an entirely new seating manual intended to assist engineers in the design and selection of vehicle seats and components.

In the aerospace field, a new committtee on training is studying requirements related to flight simulators and other training equipment techniques and practices. The Oxygen Equipment Committee continues to study the physiological and technological problems associated with the use of oxygen in high altitude flight.

The Aerospace Environmental Control Systems Committee is studying problems of maintaining suitable pressure and environment in aircraft and space vehicles. This Committee was responsible for the release of a comprehensive book entitled, "Aerospace Applied Thermodynamics Manual," covering all aspects of aviation and space environmental elements.

AMERICAN LIMITS ESTABLISHED FOR INTERNATIONAL TV AND RADIO IGNITION INTERFERENCE

Concerning vehicle radio interference, acceptable limits were established on the amount of radio and television interference produced by the ignition systems of passenger cars and trucks. These SAE recommendations are being used to present the American viewpoint in developing international recommendations on ignition interference.

In 1960, the Iron and Steel Technical Committee celebrated its 50th year of continuous service to the Society. ISTC noted the year with a number of new specifications and test methods; a document to measure stresses by X-ray and the initiation of work on carbon steel bands. The outstanding accomplishments of this group were recognized by special letters of commendation from the Automobile Manufacturers Association and the American Iron and Steel Institute, as well as the SAE Board of Directors.

Regional Section Officers Conference at Cleveland

SECTIONS BOARD PROGRAM SPARKS SAE'S SERVICES IN LOCAL AREAS

Taking off from the firm platform established by its predecessor, the former Sections Committee, the SAE Sections Board has pushed programs to improve quality of local SAE activities.

Recognizing the need for improved communications between the Sections and Groups themselves, and between these units and the Sections Board and the Board of Directors, the Sections Board immediately took two steps which are proving effective:

1. Appointment of fifteen Sections Board Area Coordinators, each as liaison between the Sections Board and several local Sections and Groups. These Area Coordinators assist Section and Group officers to organize for effective service to local members; convey their questions and suggestions to the Sections Board; keep local Governing Boards posted regarding policy matters which pertain to Section, Group, and local student activities. A Sections Board Area Coordinator News Letter is circulated periodically as an information source for Area Coordinators.
2. Organization of Regional Section Officer Conferences to stimulate inter-Section discussion of Section programs and problems. Following two successful trial conferences held in Vancouver and Chicago in 1959, Regional Section Officer Conferences were held in four areas in 1960,—New York, San Francisco, Cleveland, and Tulsa. Reports of regional conferences are circulated to all Sections.

SECTIONS BOARD FINANCE COMMITTEE'S SUGGESTIONS

Among other aids to Sections, the Sections Board Finance Committee has made available pertinent information based upon analysis of Section budgets; has developed a new Section Financial Analysis and Budget form; and a companion monthly report form. At the Finance Committee's suggestion, the Sections Board approved, on a trial basis, a systematic method of reimbursing Sections from their dues accounts. Also, the Board of Directors has authorized the Sections Board, in its discretion, to approve supplemental appropriations of up to $150 to individual Sections and Groups which need additional funds to effectively serve local members, when such requests are made by Governing Board Action.

In connection with Section affiliations with local organizations, the Sections Board Administrative Committee has simplified the previous petition form and information sheet covering such affiliations.

THREE NEW STUDENT BRANCHES; 56 NOW ACTIVE

The Student Activities Committee of the SAE Sections Board has had an active year. Most important has been development of activities which led to Board of Directors' Action granting SAE Student Branch Charters at three schools: Manhattan College, Milwaukee School of Engineering, and San Jose State College. These welcome additions bring the count of active SAE Student Branches to 56, with several potential additions in the offing.

THREE NEW STUDENT BRANCHES APPROVED

An overall drop in engineering school registrations, coupled with increased campus competition with other student organizations, has resulted in a decrease in SAE Student Enrollment. The September 30 figure was 4,068 as compared with 4,394 a year ago. An upward trend in new enrollments during the year, 2,250 as compared with 2,118, indicates a probable upturn next year.

Special student sessions sponsored by Southern California and Metropolitan Sections in connection with east and west coast National Aeronautic Meetings, Engineering-Student and Father-and-Son night at the Annual Meeting, sponsored by the Student Activities Committee and the Detroit Section respectively, coupled with numerous other Section sponsored student affairs are developing increased student interest.

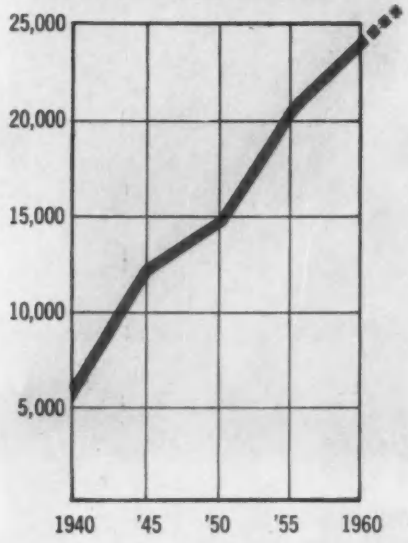
"Student-Gram," a quarterly publication on student activities, has helped in the interchange of information between the Student Branches and serves to bring them helpful data generated by the Student Activities Committee and others. Another Student Branch aid is the "SAE Student Branch Ideas Booklet," designed to help student officers plan activities in addition to their regular technical meetings.

STUDENT ACTIVITIES COMMITTEE PUBLICATIONS

During the fall, recognition and appreciation plaques have been presented to SAE Student Branch Faculty Advisors, including a special citation to Professor Erwin H. Hamilton who retired from teaching at New York University and relinquished his post as Faculty Advisor to the SAE Student Branch at the school, which he had held since he was instrumental in organizing the Student Branch in 1929.

Up to September 30, there were 313 of the 1959 graduating SAE Enrolled Students who filed applications to continue their SAE affiliations as members of the Society. SAE Enrolled Students, whose enrollments expired in September, have until March 31 of this year to file applications if they desire to have their initiation fee waived and first year dues held to $6, a new low rate voted by the Board of Directors at their April 8th meeting.

SAE MEMBERSHIP GROWTH INDEX CHART



MEMBERSHIP PROGRAMS MOVING UP

The first fruits of a diversified membership program conducted through the Membership Committee's three subcommittees in different areas of SAE activity became amply evident in 1960.

A new specialized membership program, "Pilot Project," was offered SAE local Section areas as part of the "ideas package" of the Sections Membership Program Subcommittee. Sections adopting "Pilot Project" pinpointed firms within their territory for a concentrated membership program, calling on leading SAE members in management positions for support.

New promotion folders are in the making to emphasize engineering areas in SAE's scope not now represented. They are coordinated through the Engineering Activity Membership Program Subcommittee. The efforts of this Subcommittee also produced names of more than 400 membership prospects of high caliber. In addition, 1,500 guests at National Meetings were urged to file applications for membership

SAE BENEFITS AND SERVICES DEPICTED

The Society's benefits and services were brought to the attention of 700 members of SAE Technical Committees who do not hold Society membership through the Technical Membership Program Subcommittee.

Membership applications in the 1959–60 fiscal year nearly equalled the previous year — 2,091 compared to 2,143. Overall paid membership was 24,051 at the close of the fiscal year, September 30, which is the highest figure in Society history. Names of all newly elected members, as well as of applicants for membership, are published in the SAE Journal.

The Membership Committee has worked closely with the Membership Grading Committee in carrying out the Society's policy to emphasize quality in seeking additions to the Society's rolls.

STUDENT GRADUATES ACCEPTED FOR MEMBERSHIP

The Membership Grading Committee, in its advisory capacity to the Board of Directors, reviewed and recommended action on 1,498 applications for membership and 530 applications for transfer. In addition, 486 former SAE Enrolled Students who had earned their degrees were recommended for election on the basis of their graduation from engineering courses in approved schools.

Ninety applicants were judged not eligible for membership, largely because of insufficient technical training and/or experience. At the recommendation of the Membership Grading Committee, the Board of Directors issued a statement to all Section and Group Governing Boards calling attention to the definitions of membership grades and emphasizing the importance of inviting only those who are fully qualified to apply for membership.

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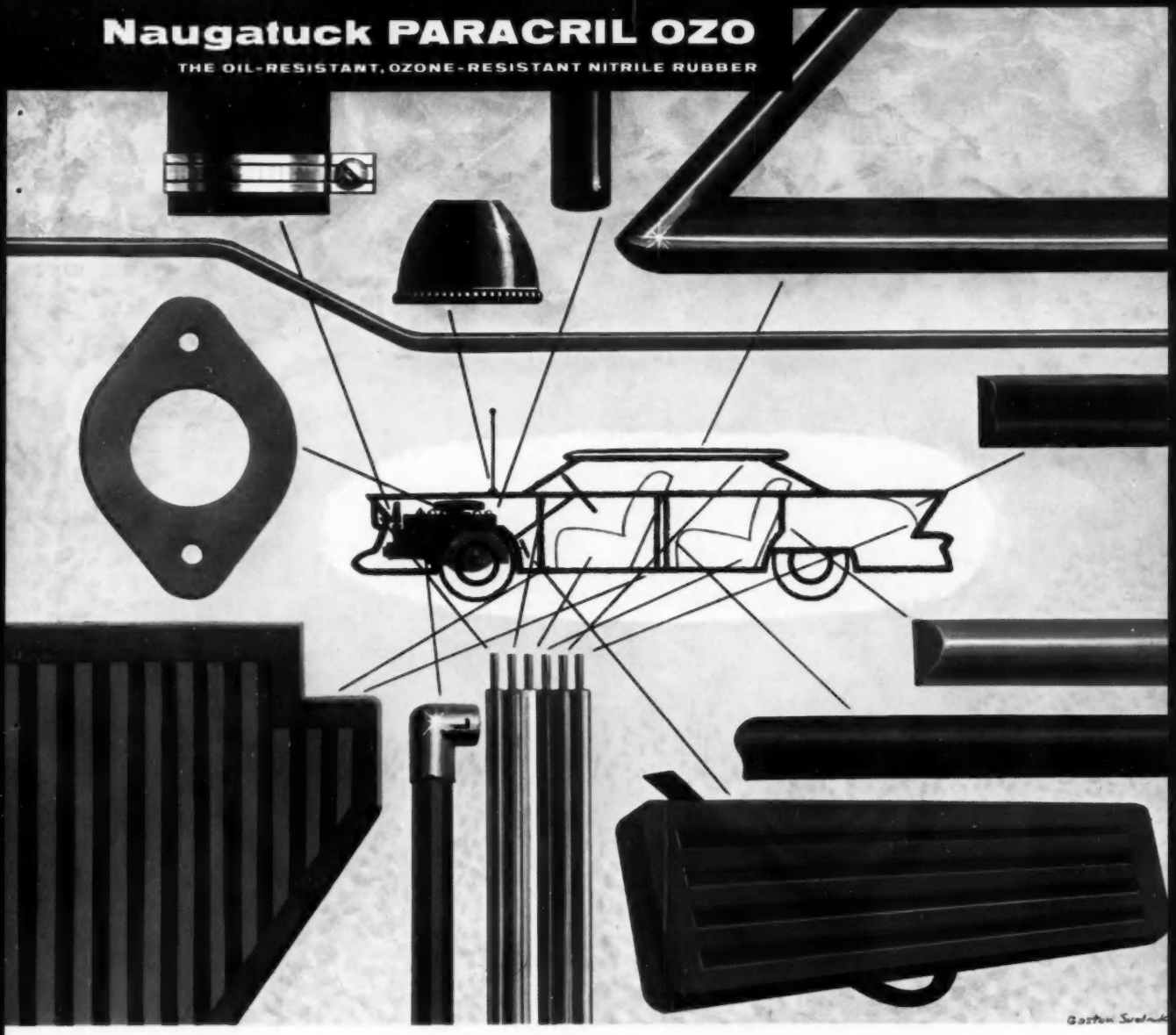

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Continued from page 89

complishment of this complex task sequence requires maintenance of proficiency. The time stress involved will make overlearning and continued practice important, since both serve to increase the rapidity with which procedural tasks can be done to decrease the thought and attention which must be given to the accomplishment of tasks of any type. On-board simulation of these task sequences, therefore, becomes important.

5. Space crew training devices in general can be so designed as to be economical to operate and maintain.

Existing human engineering and maintainability engineering data can provide design guidance resulting in effective instructor and student stations and in modularization of training equipment components in such ways as to promote ease in programming, operation, and maintenance.

6. Environmental factors may be dealt with separately or in combination, and analysis is needed to determine the relative merit of each.

Most deviations of environmental factors have some psychological effect, and a major weakness of simulation is that proper phychological overlays cannot be applied to task situations. It is necessary, therefore, to use personnel selection techniques which will determine psychological fitness. Motivation, ability to think and act under stress, and resistance to panic are of major importance.

7. Training aids may be used for indoctrination and their use may facilitate the employment of, or make unnecessary, certain simulators.

It has been demonstrated that handbooks, simple flow diagrams, block diagrams, motion pictures, film strips, and other relatively simple devices can be used to impart stored information needed for adequate task performance where perceptual-motor skills play a minor role.

■ **To Order Paper No. 245D . . .** from which material for this article was drawn, see p. 6.

New Truck Ignition Systems Held Promising

Based on paper by

M. F. BECKER
Chrysler Corp.

THE search for a better truck ignition system is still going on. High-frequency, electronic, electrostatic, low-tension, and transistor systems have been considered and of these the low-tension and transistor systems appear most promising and are being actively investigated

The low-tension system uses a spe-

Continued on page 125

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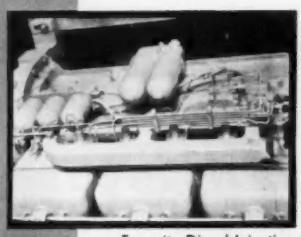
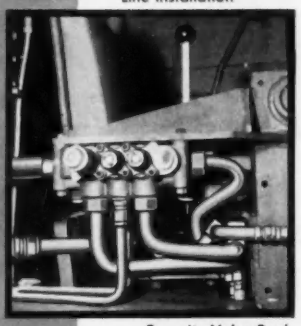
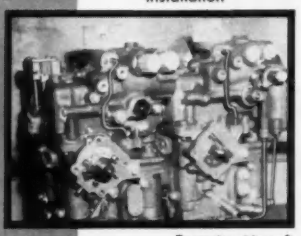


Formrite Diesel Injection Line Installation



Formrite Valve Bank Installation



Formrite Aircraft Installation

Formrite specializes in the design and fabrication of precision formed metal tubes for fluid transfer lines. In addition, the firm has extensive lines of tube fittings in a wide variety of shapes and a large range of sizes. Forgings, castings and flange mounted fittings are also available and can be machined to exacting requirements.

Whatever your fluid transfer line requirements, they can be fulfilled by Formrite – a leader in engineered fluid transfer applications.

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Continued from page 123

cial surface gap spark plug, which is very cold yet practically immune to fouling. For this reason, one type of plug will take care of all engine operating conditions. Sparking occurs over the surface of a semiconducting material between the two concentric electrodes. A special high-energy power supply is used to produce the approximately 4000 v required to fire the plug. This system is still in the development stage.

Transistorized System

One of the problems associated with the conventional ignition system has been the limited current carrying capacity of the distributor contacts. The transistorized system overcomes this. The germanium transistor itself carries the main current and does the "on" and "off" switching. Although contacts are still used, they carry very little current, much less than an amphere, and serve only to trigger the transistor. The life expectancy of the contacts is greatly increased because metal transfer and oxidation are practically eliminated. Efforts are now being made to do away with the contacts and use some other triggering means.

The higher current carrying capacity of the transistor, together with a special transformer, has resulted in a higher voltage output from the system as well as a more constant voltage throughout the engine speed range. The germanium transistor is temperature limited to about 165 F, hence must be located where the limit will not be exceeded. Usually, it is separated from the transformer package and mounted on its own heat sink so that it can be installed in a cooler spot.

The transistorized ignition may be the next step toward the ultimate goal of a system giving life-time, trouble-free service.

Material in this article is drawn from one of seven papers included in SP-188 —Reliable Electrons. **To order SP-188, see p. 6.**

Failure Rate Provides Desirable Measurement For Parts Reliability

Based on paper by

D. C. BEERY

Norair Division, Northrop Corp.

FAILURE RATE — as a requirement to be included in all part definitions — is the simplest and most desirable approach to a quantitative value for reliability. Minimum conditions to be included in the definition of such a

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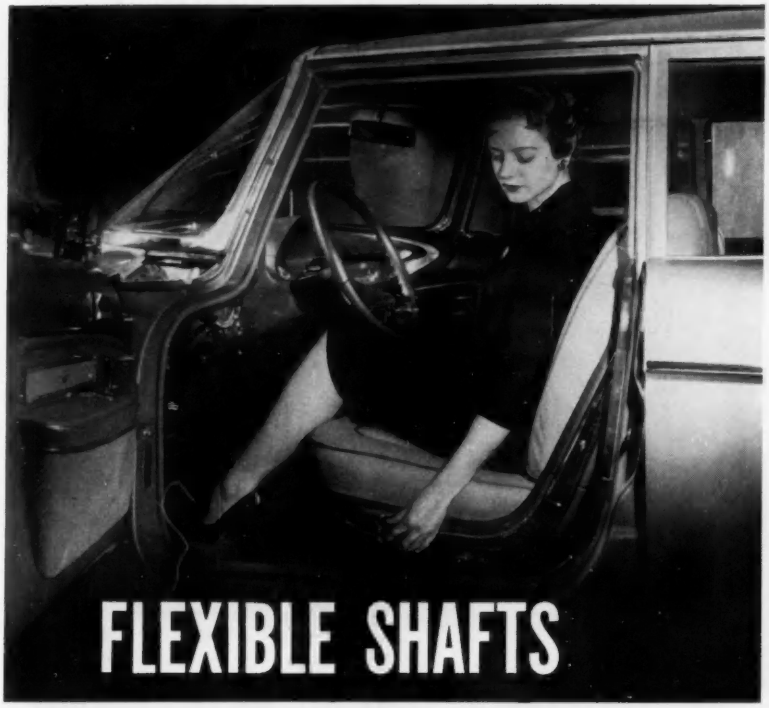

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4. LOW COST . . . "flexible shafts definitely represented savings without sacrificing design advantages."

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Payloader H-70—photo courtesy The Frank G. Hough Co.

R/M sintered friction development use-proven in over 6000 Payloaders

The Hough-built "PAYLOMATIC" P-600 full power-shift transmission utilizes a wet-friction application jointly developed by The Frank G. Hough Co., Libertyville, Ill., and Raybestos-Manhattan.

No friction failures

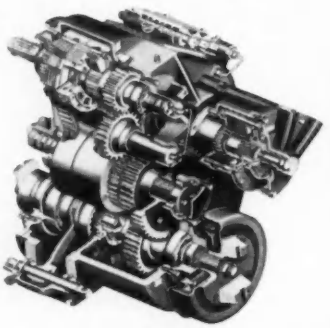
Project engineer Harry Wilson says: "We have over 6000 units in the field. There hasn't been a friction failure in the lot. The design we developed with R/M's cooperation has been use-proven. We're well satisfied with R/M's ability to help design and then deliver a superior friction material at a competitive price."

Several types of materials were tested in R/M laboratories and then on Payloader tractor shovels. Sintered bronze was the material chosen for the friction plates. Plate speeds range from 1370 to 6140 rpm; gross plate pressure to 180 psi.

Unbiased recommendations

Wherever you are, one of R/M's 25 sales engineers can be at your desk within 24 hours to help you tackle *any* friction material problem. *Only R/M manufactures all types of friction materials—your assurance of unbiased recommendations!*

Send for your free copy of R/M's Bulletin No. 501. It is packed with helpful engineering information. Write today.



"PAYLOMATIC" full power-shift transmission; 3-speed, fully reversing, constant mesh, countershaft type with balanced, rotating, hydraulic clutches continuously pressure-filled, cooled and lubricated.

This sintered friction plate, OD 5¾ in., is used in an oil-immersed application in "PAYLOMATIC" transmissions. The number of plates and the ratios vary between the models to meet torque requirements.

RM

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Continued from page 125

reliability requirement are:

- Maximum acceptable failure rate.
- Functional and environmental conditions to be imposed during demonstration.
- Confidence level to which measurement is to be demonstrated.
- A statement defining acceptable performance.

Environmental and functional stresses influence failure rate. A part not subjected to extreme temperature stresses will have a lower failure rate than one that is. And the rate will also vary depending on the degree of rated capacity to which the part is subjected.

Since failure rates are determined most practically by statistical measurement, the basic considerations of such measurement must also be provided. Sample size and minimum operating time are established on the basis of confidence levels. Therefore, provisions for measurement should include either the minimum confidence level to which the measurement is to be demonstrated, or the sample size and minimum operating time for the test samples.

Acceptable performance during the measurement tests usually is somewhat less than the maximum capability of the part or component. If all failures were catastrophic, that is, all function ceased at the time of failure, this condition would be of lesser importance. However, functional failure is also defined as performance outside of defined limits or tolerances. A statement of what is acceptable performance is desirable and often mandatory to provide a basis for meaningful measurement.

Failure Rate Measurement

Complex systems using many parts require an average failure rate that is a relatively small value. A system failure rate of 0.1/1000 hr will require the average part failure rate to be 1.0/1,000,000 hr if there are 100 parts in the system, 0.1/1,000,000 hr if there are 1000 parts in the system, and 0.01/1,000,000 hr if there are 10,000 parts. Fig. 1 shows the relationship between failure rate and failure-free test hours. The value for the test hours represents the minimum test time to provide assurance of the maximum failure rate for the confidence levels shown. It is evident that, to demonstrate a failure rate of 1.0/1,000,000 hr at a 50% confidence level, 660,000 failure-free test hours will be needed; for an 80% confidence level, 1,600,000 failure-free hours, and for a 95% confidence level, 3,300,000 hours. A confidence level of 50% is not generally acceptable when reliability is involved, but 80% can be assumed to be.

The failure-free test hours required to demonstrate a failure rate of one failure per million hours of operation are considerable, even at a level of 50% confidence. When time is lacking or

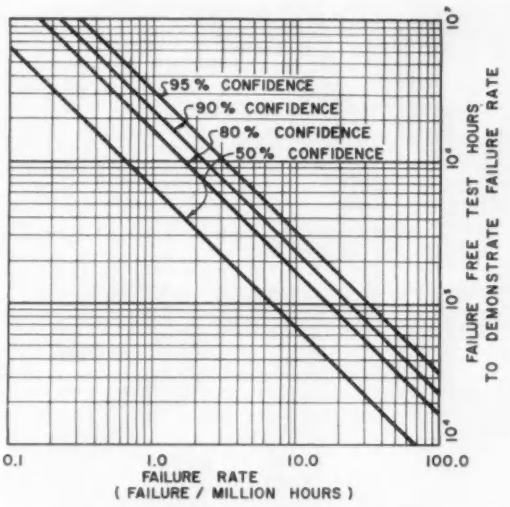

Fig. 1 — Relationship between failure rate and failure-free test hours. The failure-free test hours needed to demonstrate the rate of one failure per million hours of operation rises with the confidence level.

test costs are prohibitive, the usual test methods become impractical and other methods of measurement or control must be used. Statistically designed tests, such as are included in MIL-R-26667 and MIL-R-26474, can be used to establish acceptability with less test time. Analytical evaluation of the probable failure modes can be used to specify material, process, or product controls to maximum probability of acceptable reliability. The burden of reliability proofing is then transferred from the procurement area to the area of installation and use.

■ **To Order Paper No. 235C . . .** from which material for this article was drawn, see p. 6.

Small Electronic Parts Undergoing Intense Sound Need Proper Mounting

Based on paper by

DENIS U. NOISEUX

Bolt Beranek & Newman, Inc.

WHEN an electronic package containing small components is exposed to high intensity sound, the components are simultaneously excited in two ways:

- The sound pressure inside the package is applied directly at the surface of the components and excites it into some vibration.
- The sound pressure outside and inside the package excites the structure of the package (panels, printed circuit boards) on which the electronic components are mounted.

Analysis of elementary cases of rigid and resilient mountings helps to answer the following questions in regard to minimizing the effects of the component vibration resulting from the vibration of the structure on which the component is mounted:

- Should a component be mounted rigidly or resiliently?
- Is there a preferred orientation for mounting a sensitive component on a vibrating plate?
- What vibration tests should a sensitive electronic component be given?

Rigid or Resilient Mounting?

It appears that rigid mounting is to be preferred to resilient mounting. The possibility of resonance of the loaded plate coinciding with a resonance of the resiliently mounted component is this avoided. This coincidence would lead to rather large motion of the electronic component, because the amplification factors of each resonance are multiplied together. The stresses applied to the electrical leads or the electrical noise induced in the electronic component would lead to a rapid failure. Although the probability of a coincidence of resonance of the plate and of the mounted component is very small, the net probability increases with the number of components mounted on a given plate. The result

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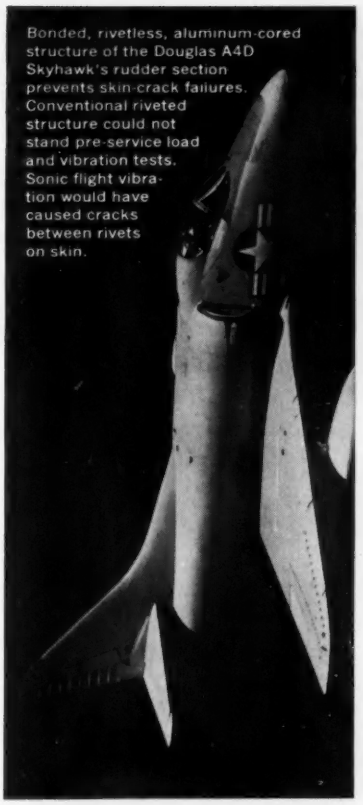
Bonded, rivetless, aluminum-cored structure of the Douglas A4D Skyhawk's rudder section prevents skin-crack failures. Conventional riveted structure could not stand pre-service load and vibration tests. Sonic flight vibration would have caused cracks between rivets on skin.

Photo courtesy Douglas Aircraft Company, Inc.

11 Ways Ray-BOND Adhesives Solve Tough Fastening Problems

New bonding and laminating techniques at R/M help solve difficult fastening problems and thereby make possible many of the new products being developed and produced by America's advancing technology. The advantages of Ray-BOND adhesives include:

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Continued from page 127

is a finite probability of serious damage.

With rigid mounting, the electronic component is an integral part of the vibrating plate. Stresses resulting from the vibration of the loaded plate distribute themselves according to the net relative stiffness of the mounted components and of the supporting plate. In order to limit the value of the stresses in the electronic components, many such components must be mounted rigidly on a given plate. Then the stresses are distributed safely among the components. Printed circuit boards painted with epoxy so that the electronic component is cemented to the board have been used in the industry with good success. Resonance of the component mounts are essentially eliminated; in addition, the epoxy provides substantial dampening and stiffening of the loaded plate.

If resilient mounting of an electronic component must be used, for example, because that component is fragile, one should provide dampening of the supporting plate and of the resilient mount itself. This is an insurance against the possibility of a coincidence between a plate resonance and a mount resonance.

Orientation?

Even in the simple case where an electronic component is rigidly tied to one point of a vibrating plate, five out of its six degrees of freedom (assuming a rigid component) can be excited: the three rectilinear motions and two out of three angular motions. The orientation of the component with respect to the plate will determine which of these motions are more strongly excited. However, one should take advantage at least of the fact that angular motion about an axis perpendicular to the vibrating plates is not, in this simple case, directly excited. For example, in the design of a relay, the axis of the moving armature should be along a line perpendicular to the surface of the plate on which it is mounted; of course, the armature itself should be symmetrical with respect to its axis. The only (to a first experimentation) degree of freedom of the armature is, therefore, not excited by the vibrating plate. Some relays of recent and successful design have satisfied this condition.

Which Tests?

The vibration tests to be given to electronic components themselves depend on their mounting technique. For either rigid or resilient mounting, analysis has shown that both rotational and rectilinear motions are present. In a certain frequency range, a set of angular and rectilinear motions is excited; as the frequency is increased and the plate is excited into other modes, other sets are excited. Tests involving simultaneously excitation of rectilinear and rotational accelerations are thus demanded. Such tests are indeed prohibitively expensive; much more, test techniques for simultaneous rectilinear and rotational accelerations have not yet been developed. In the case of critical and sensitive components like vacuum tubes or relays, one should consider at least to perform separate rectilinear and rotational tests. In the rectilinear tests, the electronic component can have its axis oriented at some angle with respect to the direction of excitation. Thus, the three coordinates of the component can be excited simultaneously by a single direction of excitation. Two such tests, one with the major axis of the component rotated 90 deg with respect to the other should be adequate. One can control the relative excitation along the three axes with respect to the direction of excitation. The same approach can be applied to a rotational test.

Even with this "simplified" testing procedure, the cost of testing is still very great. However, if the manufacturer or designer of electronic components would perform these tests early in the development or at least in the prototype stage, the relative importance of rotational and rectilinear excitation for this specific component

Continued on page 131

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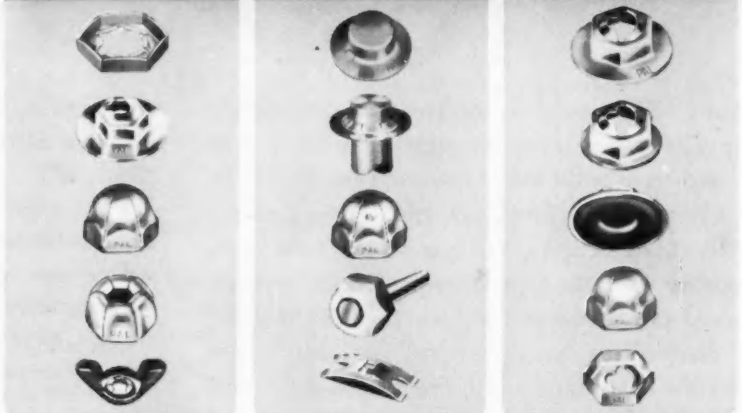

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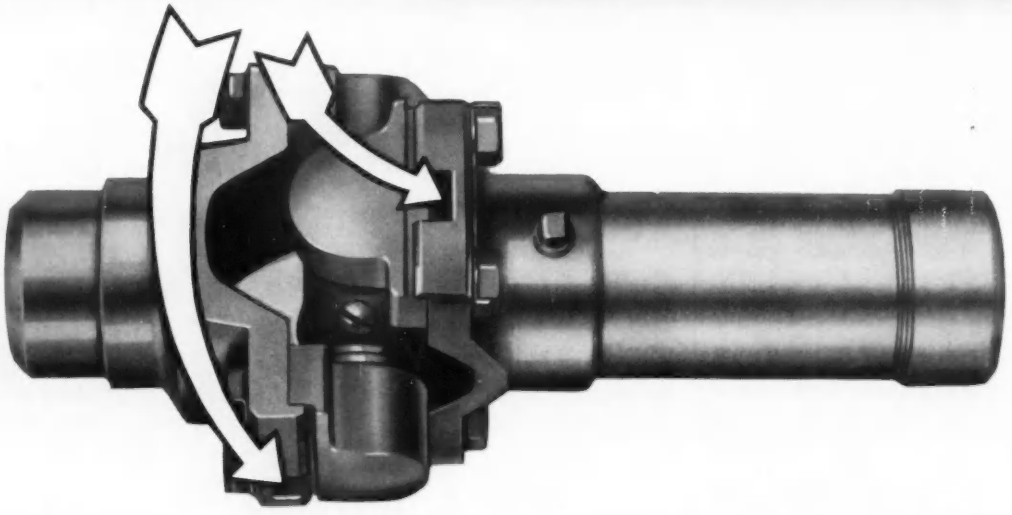

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Continued from page 129

would be established and the component, from then on, would be tested primarily at its most sensitive orientation — rectilinear or rotational — to ensure quality production.

For some components, like vacuum tubes, it may be sufficient to establish that, perhaps, a rotational acceleration test does not excite electrode vibrations in a different way from rectilinear acceleration.

When the rigid mounting technique is used, the electronic component becomes an intimate part of the vibrating plate; the component shares the bending stress of the component plate: tension, compression, and shear stresses. It follows that some evaluation of the stress sensitivity of susceptible electronic components should be made. For example, fragile components like ceramic capacitors cemented on a vibrating plate are likely to break under the bending stresses.

■ To Order Paper No. 236C . . . from which material for this article was drawn, see p. 6.

Buick Reliability Features Four Phases

Based on paper by

J. R. GRETZINGER

Buick Motor Division, GMC

Material drawn from an

SAE Detroit Section Paper

BUICK'S reliability program has four phases. They are:

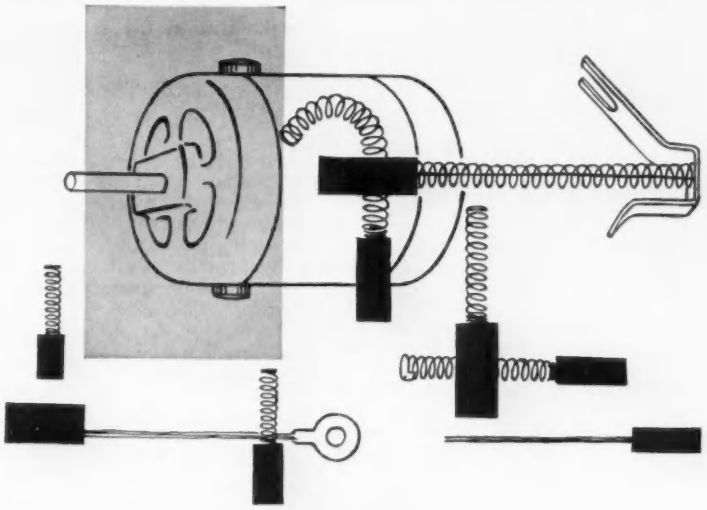
- The design phase, which starts with the first drawing release.
- The test phase, which starts with the first development testing.
- The production phase, which is concerned with processing, manufacturing, and quality control.
- The customer service phase.

Design Phase

The following are a few major details of the design phase:

1. The part design is reviewed. In other words, we get into the details and study the design.
2. All historical reliability data is coordinated and compared with any data available on a similar product. The historical data becomes permanent reference material upon which to build.
3. An initial reliability prediction is made using the accumulated data and knowledge contributed by the engineering department. This prediction and all other predictions are used as devices to highlight problem areas that require attention, and, of course, the

Continued on page 132



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Custom-Engineered
BRUSHES
for all rotating electrical equipment

Continued from page 131

reliability figure assigned to each one gives a measure of the severity of the problem.

Testing Phase

The following are important areas within the testing phase:

1. Engineering the tests. We obtain as much information as possible and compare the test program with what tests we think should be run, considering critical items in the design. This information helps to plan future tests.
2. Prototype testing by engineering.
3. Making available the results of the engineering tests. As engineering makes redesigns, predictions are changed. It is our job to see that the engineering test program exposes weaknesses in the reliability of the product.

Production Phase

After the engineering design is released and the process and quality control groups go to work, we study the processing and quality control plans to determine if the critical parts of the design are going to suffer any loss in reliability during the production phase.

Next comes the production reliability test. Here, a percentage of the production is submitted to severe test for a limited period of time. After the test, the items are checked for condition and wear.

Customer Service Phase

The following action is taken on field problems:

1. Evaluation of field failures.
2. Corrective action of design or quality.
3. Organize field information into useful engineering data.

This approach to reliability will result in continual refinement of the product to improve reliability. The result: a product which has been debugged by the time it reaches the customer.

■ **To Order Paper No. S260 . . .** from which material for this article was drawn, see p. 6.

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43 YEARS OF ENGINEERING LEADERSHIP

Driver Use of Clutch Can Damage Drivelines

Based on paper by

C. A. CARLSON

International Harvester Co.

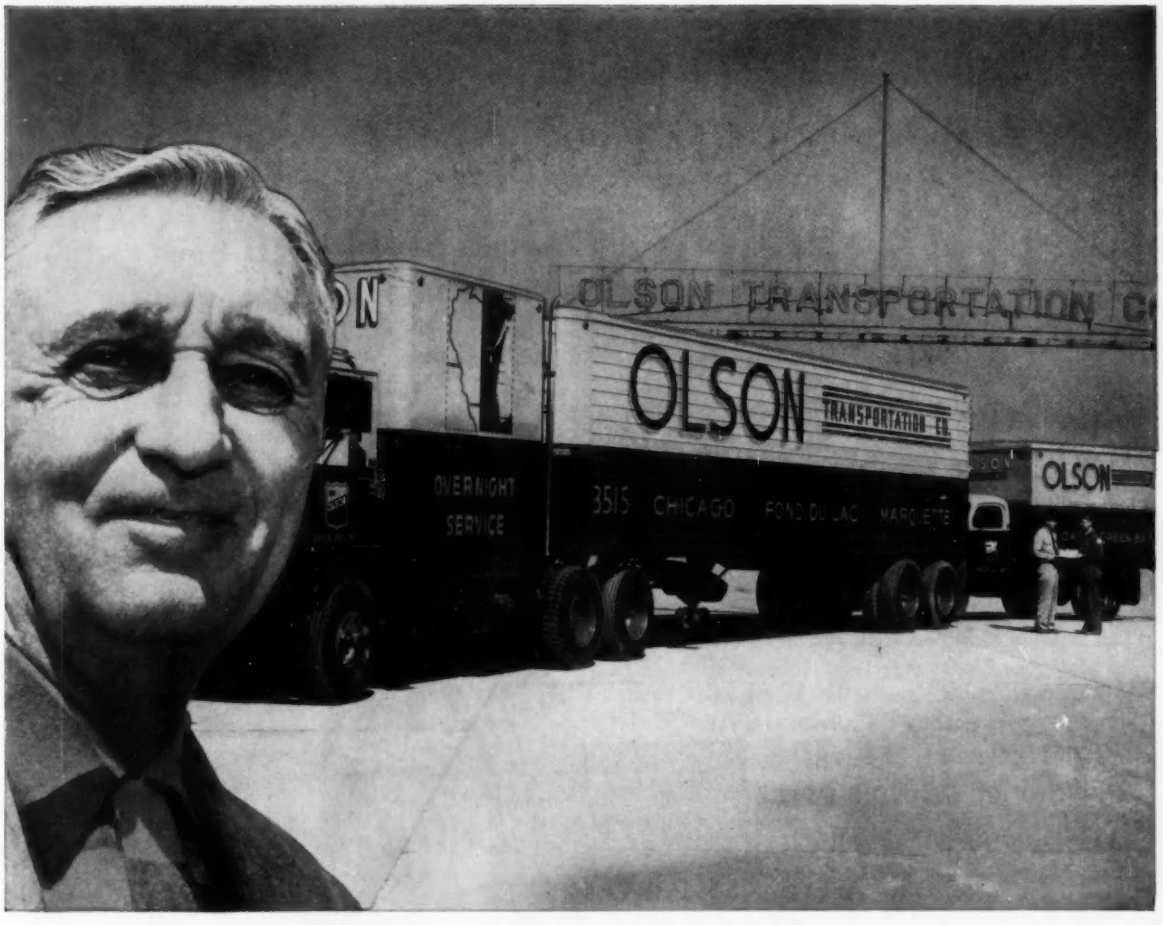
DRIVELINE components can be damaged by repeated impact engagements of the clutch. This is particularly true if these engagements are made at a high engine speed. In vehicles having an auxiliary transmission — thereby making as many as 10 selections of total gear reduction possible — the most detrimental impacts will generally be obtained in the intermediate gears.

Selection of the higher gears (low total gear reduction) results in lower torsional impact as limited by clutch slippage. Selection of low gears (high total gear reduction) results in lower torsional impact.

Analysis proves that the designer must consider the fact that the drive train can be subjected to much higher torque values than those represented by the maximum engine torque. Even using the best steel available and the best possible heat-treatment for a given application, it is not feasible to produce a vehicle which can be subjected to the most severe impact torque possible for an infinite number of applications.

This would require excessively large rear axles, drivelines, and transmissions, thereby greatly reducing the vehicle payload and greatly increasing its initial cost to an impractical degree. To meet this situation, a factor of safety is used in the design of these components which will permit a reasonable number of severe torsional impacts during the life of the vehicle. It should be borne in mind, however, that repeated vehicle operation of this type can result in damage to these components.

■ **To Order Paper No. 253A . . .** from which material for this article was drawn, see p. 6.



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says Olson Transportation Co., Green Bay, Wisconsin

M. J. Madigan, Olson Maintenance Superintendent, remarks: "Some time back, we decided to give Lipe Clutches a thorough tryout as interchanges for original equipment. Our records show that they have produced more miles before overhaul than the clutches supplied with our units when new. Needless to say, we are very satisfied with these results."

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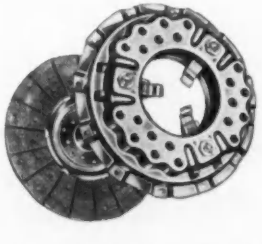

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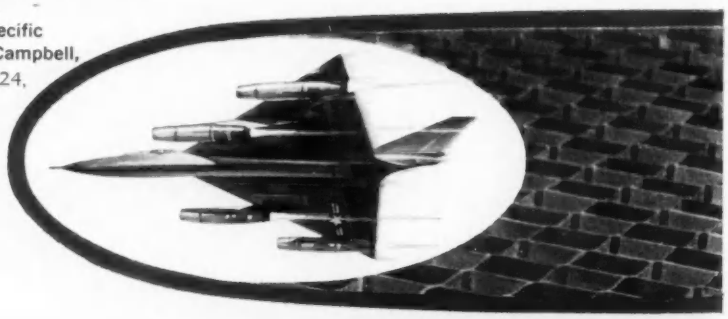

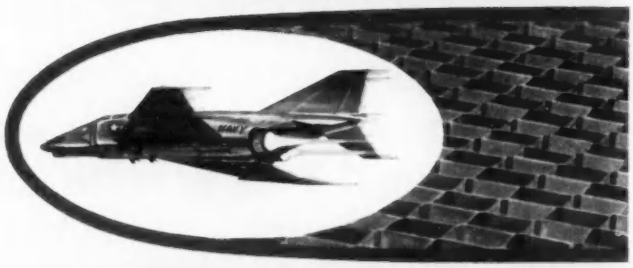

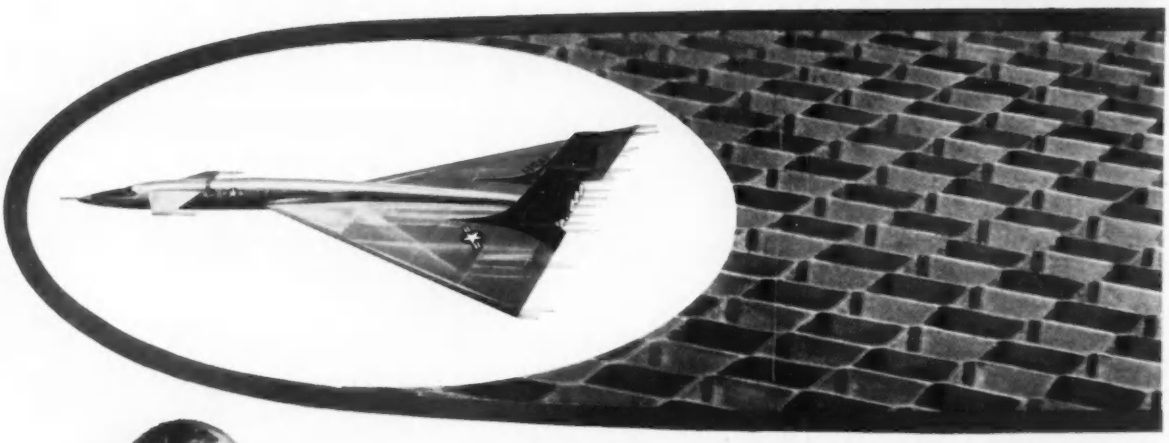

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Continued on page 140

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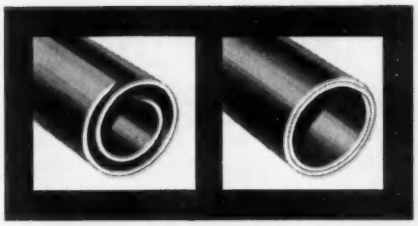

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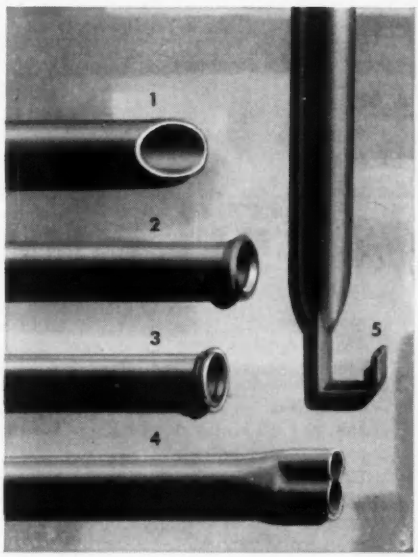

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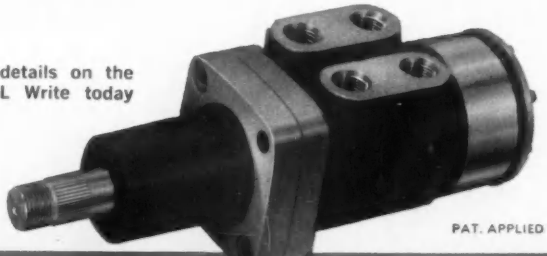

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Southern California Section: Walter Fredrick Hooper (J), Theodore G. Thometz (J), Laurence Wisberger, Jr. (A).

Texas Section: Truman L. New (J).

Twin City Section: Gerald Roy Knutson (J).

Washington Section: James Louis Kurtz (J), Ivar C. Peterson (M).

Wichita Section: G. L. McCumber (A).
Outside Section Territory: Garth Anthony Clowes (M), Roy E. Harrington (M).

Foreign: Arturo Bernal S. (M), Mexico; Ernst Karl J. Gassner (M), Germany; Ames Ishai (M), Israel; P. R. Keen (J), Sweden; Bindu Bandiatmakur Madhava Rao (M), India; Howard Arthur Pendergrast (J), South Australia; Yutaka Shirai (A), Japan; Horace Robert Swatman (M), England.

Applications Received

The applications for membership received between November 22, 1960 and December 22, 1960 are listed below.

Alberta Group: Arnold Bohni, Percy Victor Clarke, Graham Scott Montgomery, Harold Albert Nelson

Atlanta Section: John R. Curtis, Robert H. Patterson, Jr.

British Columbia Section: James Wilson Colbran, Edmund Joseph Nicholson, William Ellis Patey, Christopher Charles Perry, Jack H. Ralston, Russell J. Rutledge, Leslie Smith

Buffalo Section: Charles Calder Park, Robert E. Weider

Central Illinois Section: William G. Turnbull

Chicago Section: Jack W. Durham,

Continued on page 143

HEADQUARTERS

for tough valve gear problems

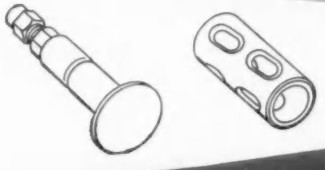
When you're facing difficult problems involving valve gear, the men to see are Chicago's tappet engineers. For, in 25 years of specialization on valve train parts, we have encountered and solved many problems similar to yours.

Applications, such as those illustrated, are typical examples . . . and the operational records established by Chicago tappets of all types in more than 25,000,000 engines are the best testimonial to their success in meeting the toughest industry requirements.

Even when your engine does not present unique requirements in valve gear design, checking with Chicago can often assure a performance bonus. Chicago's hydraulic tappets, for example, assure longer trouble-free life, reduced starting noise, and quieter operation.

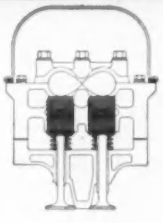
For Any Engine

Car, truck, tractor, diesel . . . aircraft, outboard, power mower, or industrial . . . whatever your type of engine, big or small . . . it will pay you to consult Chicago's development engineers *while you are still in the preliminary design stages.*

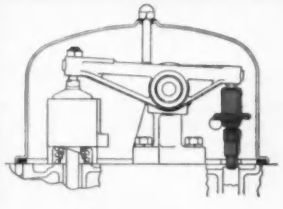


Write or wire our Tappet Division today

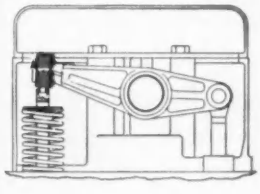
Hydraulic and Mechanical Tappets (Barrel or Mushroom Type) of Alloy Steel, Hardened Alloy Cast Iron, Chilled Iron, or Alloy Chilled Iron • Push Rods • Adjusting Screws



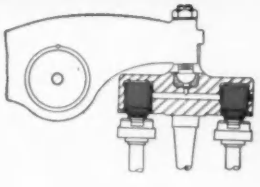
Hydraulic Inverted Cup Type Unit



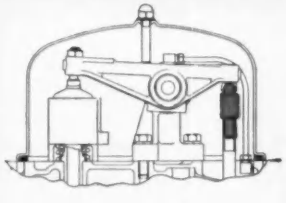
Push Rod Type with Compression Release Application



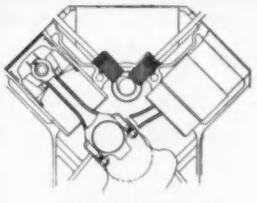
Threaded Type Rocker Arm Unit



Dual Valve T-Bridge Hydraulic Application



Hydraulic Unit on End of Push Rod



V-8 Automotive Hydraulic Tappet Application

THE CHICAGO SCREW COMPANY

ESTABLISHED 1872 • DIVISION OF STANDARD SCREW COMPANY

2701 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Methods of Carburizing Alloy Steels

Carburizing is a means of impregnating the surface of steel with carbon, usually to very limited depths. Its purpose is to provide a hard, wear-resisting "case," or outer shell. Alloy steels, correctly handled, can be case-hardened without sacrificing desirable core properties.

There are three types of carburizing in general use:

Liquid Carburizing—The medium here is a hot-salt bath composed basically of cyanide compounds. The steel is immersed in the bath, the period of immersion depending upon the analysis of the steel and the depth of case desired. Liquid carburizing is a convenient method of producing thin, hard, wear-resisting cases, generally within the depth range of 0.02 to 0.03 in. However, deeper cases may be obtained, the actual depths depending upon economics and end uses.

Gas Carburizing — This method employs a furnace in which a carbonaceous atmosphere is created; i.e., gases that are high in carbon components, or those containing carbon. Steel subjected to gas carburizing can be case-hardened to depths generally ranging from 0.01 to 0.04 in. When quenching takes place immediately after carburizing, distortion can be kept to a minimum.

Pack Carburizing — Where the pack method is used, the parts to be carburized are buried in a container of dry carbonaceous materials. The container is sealed tight to prevent the infiltration of air, placed in a furnace and kept there for eight hours or more, the actual time depending upon the depth of case desired. Pack carburizing is particularly suitable where a deep case is essential (0.06 in. and over), although medium cases in the 0.04-to-0.06-in. range are possible.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Applications Received

Continued from page 140

Howard E. Dwan, Warren Jensen, Edmond William Kraft, Henry Andrew Leidecker, Theodore D. Less, Donald Jean Lindley, Donald Robert Palmiter, Henry Ernst Rohrbein, Robert F. Schmidt

Cincinnati Section: John David Pennington

Cleveland Section: Robert J. Buettner, Edward Emri Kish, Jr., Harold Isaacs

Dayton Section: Lawrence Adams Botkin, Walter Owen Hall, Robert John Parker

Detroit Section: Robert John Allison, D. Robert Bell, Russel Daniel Briggs, Horace L. Browne, George Wilson Buike, James C. Burrous, James B. Carson, Sharad Mohanlal Dave, John Joseph Doyle, Larry H. Drake, Thomas Stowe Eccles, Steven J. Garbarino, Jr., Neil M. Goodwin, Teddy Joseph Hajjar, Dwaine W. Hubbard, John W. Jorgenson, Dan W. Kaufeld, Jr., James Michael Lane, Howard Edward Lang, Benton Brown Lindamood, Donald George Lueck, Walter Mackey, George G. Malek, Charles Mauch, William S. McDowell, Robert Strange McNamara, John R. O'Brien, Theodore Padzensky, John E. Pursell, John Edward Rossbach, Robert E. Schrock, Ivan Peter Shadko, Jack W. Spiroff, Conrad N. Reuter, Darrell C. Richmond, Donald Frederick Scherer, Phillip Denis Smitley, Peter Vaicekauskas

Fort Wayne Section: George Maxwell DeRoche, Charles D. Gebeke, Frank J. Kish, Erwin Carl Meissner, James W. K. Ying

Indiana Section: John Dudley Binford, Charles William King, Beldon Lee Rich, Thomas Wendell Williams

Metropolitan Section: Henry Larry Bungart, George J. Claffy, Irwin Otto Kamm, Joseph Martorello, Elbert Dickerson Nostrand, Edmond Norton Skinner, Charles M. Twyford, Conde Blaine Walker

Mid-Continent Section: Lavern Clifford Pelphrey

Milwaukee Section: Dale Henry Hirasuna

Mohawk-Hudson Section: James Bromley

Montreal Section: Maurice Patrick Coghlan, Jr.

New England Section: William P. Cox,

Continued on page 144

Meet Ray F. Claybrook, Holtville, Calif., with one of two Model 28 Freeman Balers he uses for custom-haying. The 30-hp VH4D Wisconsin was tailored for the machine and the job—a Wisconsin service available to you.

"Since I got my first air-cooled WISCONSIN, I haven't looked at a water-cooled engine,"

—says Ray F. Claybrook, custom-hayer

And, he adds, "I've had lots of engines with radiators." His tribute shows that it pays to use air-cooled Wisconsins on the power equipment you design or build. It especially merits your consideration because it is based on experience under severe operating conditions in the field.

Mr. Claybrook had just baled *10,500 tons* of hay. He kept his two Wisconsin-powered balers working from sun-up to sundown — often in 115° heat that sears the Imperial Valley of California.

However, "Not one of my Wisconsins missed a lick all summer," he writes. "They did the job without a change of spark plugs or points. I'm sure glad to be able to do my baling and not have to worry about fan belts, radiators, water pumps, and packing water."

Now look at *your* benefits: An air-cooled Wisconsin is smaller and lighter than its water-cooled equal. This and our custom-engineering can cut your design and assembling costs, enabling you to pass the savings on to your customers—or to improve profits.

Let us tailor the engine to your machine. Sizes from 3 to 56 hp. Electric starting, choice of fuel systems, and a host of mechanical modifications available for all models. Get Bulletins S-249 and S-254. Dept. O-21.

WISCONSIN
MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

O-269

CONTINENTAL MOTORS

WIDENING THE HORIZONS OF THE INDUSTRY IT HELPED TO BUILD

For nearly 60 years, Continental Motors has been famous for dependable internal combustion power. Today, the company whose product once gave life to more than half of all cars on the road not only continues to serve the great industry it helped to establish, but serves it in ways equally vital to that industry's well-being and growth. More and more of the specialized machines speeding the nation's mammoth highway-building program are Continental-powered. Upwards of 100 basic models—gasoline, diesel, lpg—built to some 2,000 specifications, each engineered precisely to the requirements of its job, are building satisfaction and profit for their users and for the equipment manufacturers. Road contractors, construction companies, off-highway machinery users of all kinds, are finding it truer than ever:

ALL EQUIPMENT IS BETTER
WITH CONTINENTAL RED SEAL POWER

•

TODAY'S EXPANDED CONTINENTAL FAMILY

Continental Motors Corporation • Continental Aviation and Engineering Corporation • Gray Marine Motor Company Wisconsin Motor Corporation • Novi Governor Division

BUILD DEPENDABLE POWER FOR HUNDREDS OF SPECIALIZED APPLICATIONS, ON LAND, AT SEA, AND IN THE AIR

•

6 East 45th St., New York 17, New York • 6218 Cedar Springs Road, Dallas 9, Texas
1252 Oakleigh Dr., East Point (Atlanta) Ga.

Continental Motors Corporation

MUSKEGON • MICHIGAN

Applications Received

Continued from page 143

George Ducrow, Grover King Gregory, Luciano S. Visco, Winfred Valma Walker

Ontario Section: Kurt Denneler, Ronald Holman Doolittle, Allan S. Evans, Boris Grabb, George F. Howard, Donald R. Hull, Norman P. Maycock, James Angus McDowell, James B. McIntosh, Thomas Patrick Monaghan, Roy Overton, Douglas Albert Taberner, Frank Edward Tayler, Walter James Woolidge

Oregon Section: Bruce J. Bekins, Ivan Joseph Jones

Philadelphia Section: Andrew F. Rutkiewic

St. Louis Section: Wayne Leroy Page

San Diego Section: James Lewis Wainwright

Southern Texas Group: Marvin E. Anderson

Southern California Section: A. H. Dunn, William J. Gage, Charles Lewis Landers, Jack Alfred Rassi, Duane Arnold Sanborn, Robert N. Turk

Southern New England Section: Merton Irwin Rosenberg

Syracuse Section: C. Richard McCray

Texas Section: John Czuwala, Harold Ivan Knight, Glenn R. Simmons

Texas Gulf Coast Section: Ragnar Verner Hokanson, Louis M. Landa, Jr., Hyman Dave Massin

Twin City Section: Donald J. Armstrong, Bernard George Chandler

Washington Section: Roy Albert Hoffman

Wichita Section: John C. Berwick

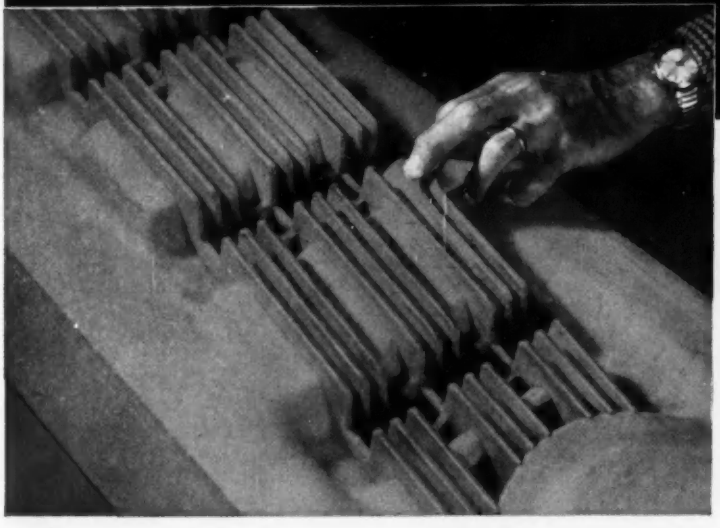
Williamsport Group: George William Daneker

Outside Section Territory: Lawrence James Bogdon, Royce B. Boykin, Russell G. Chandler, Eugene Francis Chojnowski, Donald D. Faehn, Albert C. Hoyle, Merle LaVerne Kaesser, Glenn Richard Kroeger, Robert Garry Lawrence, John Robert Shepard, Richard D. Strunk, Raul Daniel Sundstrom

Foreign: Eduardo Ramon Abril, Argentina; Joseph T. Froehlich, West Indies; Balasubramaniam Kandasarma, India; William Mckenzie Morrison, England; Arvin Ramchandra Savkoor, India; Sridhar Srinivasan, India

SILICONE NEWS from Dow Corning

Perfect Prototypes...Fast!



Silastic RTV puts designs into 3-D easily, quickly, economically

Turning intricate designs into prototypes and finished parts is greatly speeded and simplified with Silastic® RTV, the versatile fluid silicone rubber that vulcanizes at room temperature. Prototypes made with this new engineering "tool" are exact reproductions of the original patterns.

How it's done.

Here's how one automotive parts supplier uses Silastic RTV in producing small quantities of experimental grilles. The first step, illustrated at top, is a precise wooden pattern of the design. Next, plaster is poured over this pattern to form the first mold. Then, Silastic RTV takes over. This fluid rubber flows easily into the plaster mold, conforming to the finest detail, then cures at room temperature to form a firm-but-flexible *exact* duplicate of the original wood pattern.

Now, a second plaster mold is made from the silicone rubber duplicate. Alloys are poured into this plaster mold to form finished metallic prototype parts.

Why bother with Silastic RTV and the extra step? Several good reasons. First, Silastic RTV releases the plaster mold quickly, smoothly — something that's difficult with wood originals. Second, by "standing-in" for the original wood pattern, Silastic RTV protects that costly pattern from harm. Another important benefit is durability. The silicone rubber duplicate can be used over and over again!

Silastic RTV resists temperatures up to 500 F, enabling you to make prototypes directly from the RTV mold with plastics. Examples: trim parts, instrument panels and many other parts important to overall design and beauty.

Every day more and more engineers turn to Silastic RTV for help in cutting costs, in reducing time requirements, in pretesting of new designs. How can this versatile material best serve *you*? Investigate today.

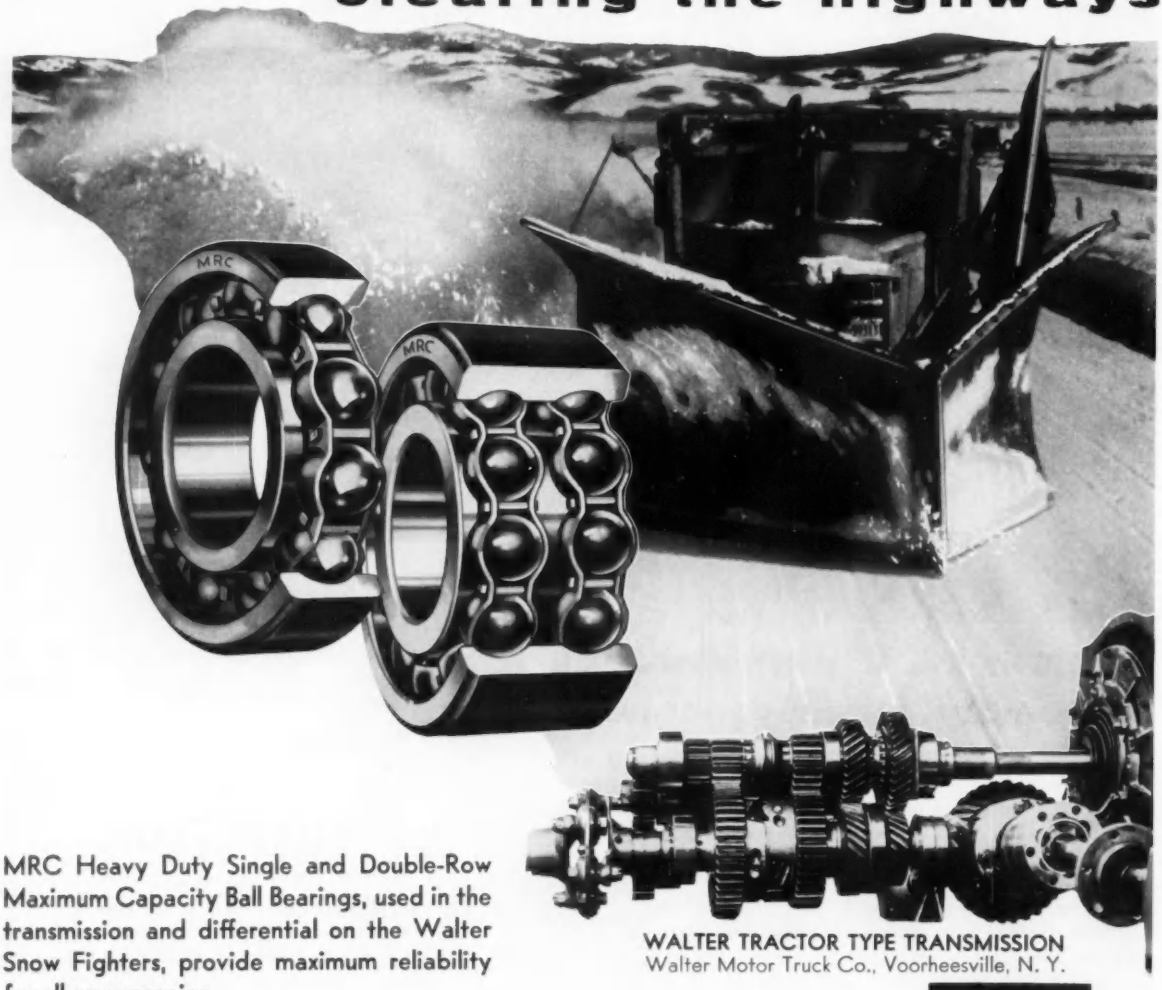
For detailed information on Silastic RTV, contact the Dow Corning office nearest you, or write Dept. 8014.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

MARLIN-ROCKWELL RELIABILITY COUNTS in WALTER SNOW FIGHTERS clearing the highways



MRC Heavy Duty Single and Double-Row Maximum Capacity Ball Bearings, used in the transmission and differential on the Walter Snow Fighters, provide maximum reliability for all emergencies.

WALTER TRACTOR TYPE TRANSMISSION
Walter Motor Truck Co., Voorheesville, N. Y.

Consult OUR Engineering Department on YOUR Bearing Problems

MRC BALL AND ROLLER bearings

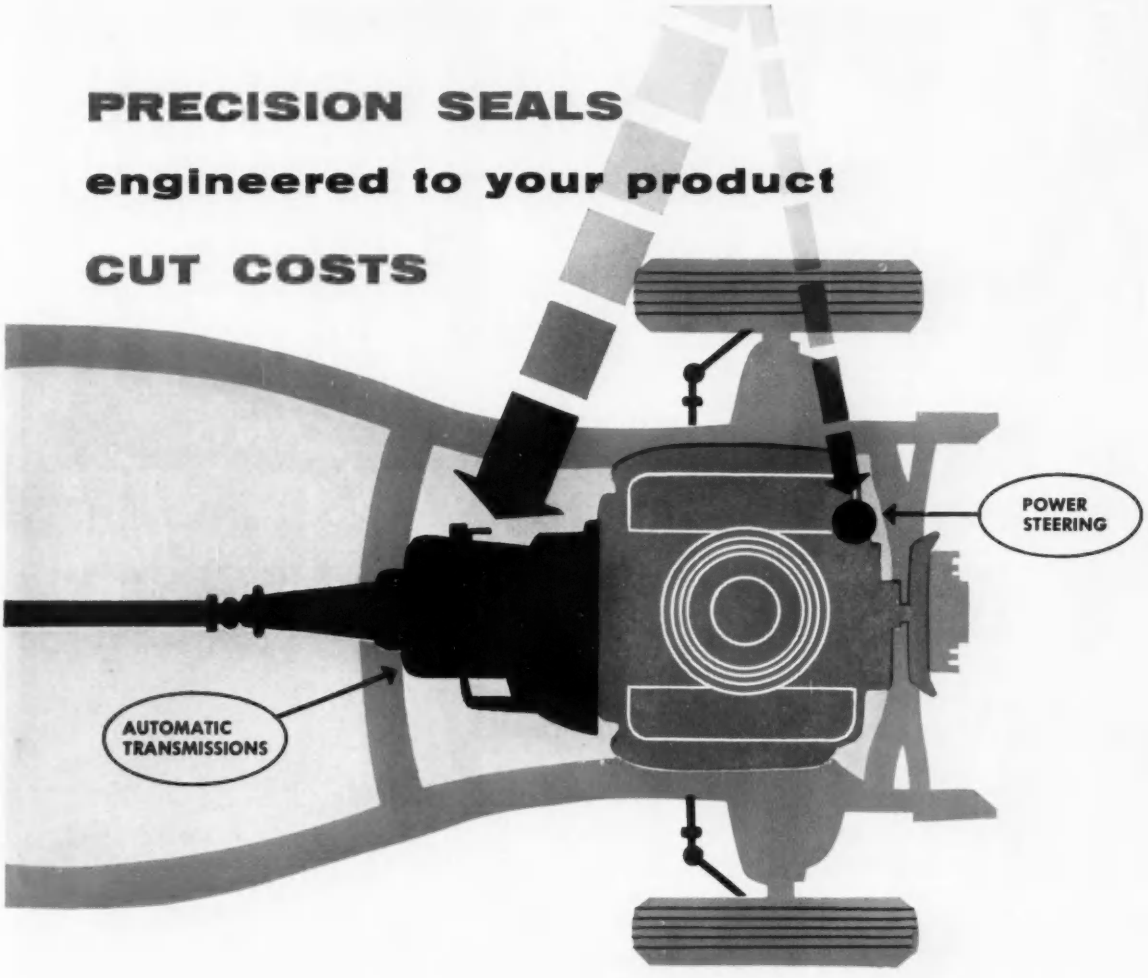
MARLIN-ROCKWELL CORPORATION

Executive Offices: **Jamestown, N. Y.**

PRECISION SEALS

engineered to your product

CUT COSTS



Problem Solving is a common occurrence at Precision. One was the development of a universal compound for automatic transmissions and power steering systems.

The Solution Precision Compound No. 6767—provided an "O" Ring with these characteristics. Suitable for all transmission fluids . . . particularly type "A" . . . long life over a temperature range of —40F to 300F . . . excellent resistance to cracking . . . low volume change . . . low compression set . . . high modulus.

Precision creative research has reduced costs by producing the right "O" Ring for many manufacturers. You can benefit too, for the services of a Precision engineer are available to help you obtain the right product design and the right "O" Ring for it. Write or phone for his services today.

Precision Rubber Products Corporation

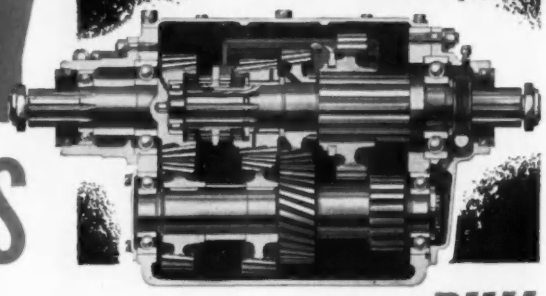
"O" Ring and Dyna-seal Specialists

3110 Oakridge Drive, Dayton 17, Ohio **Canadian plant at: Ste. Thérése de Blainville, Québec**

NEW 4-SPEED AUXILIARY TRANSMISSIONS

For Medium-Heavy-Duty Trucks and Tractors

MODELS 4-B-73 AND 4-B-75



SPLIT GEARS AND *GO*...SHIFT INTO DEEP REDUCTIONS AND *PULL*

You no longer have to pay a premium price for a 4-speed auxiliary which is heavier than your operation demands. Save weight *and* money with one of the new Fuller 4-speed Auxiliaries equipped with overdrive, direct, low and low-low gear ratios in one compact, 375-pound unit. Get gear-splitting ratios plus deep reduction.

The Fuller 4-B-73 is designed for use with engines producing approximately 500-600 lb./ft. of torque. Use of special high-capacity bearings permits the 4-B-75 to be used with engines in the 600-700 lb./ft. torque class.

Get all the extras of price, performance and payload. Specify the new Fuller 4-B-73 or 4-B-75 4-speed Auxiliary Transmissions. For full details, see your truck dealer or write Fuller Manufacturing Company.

GEAR RATIOS
Models 4-B-73 and 4-B-75

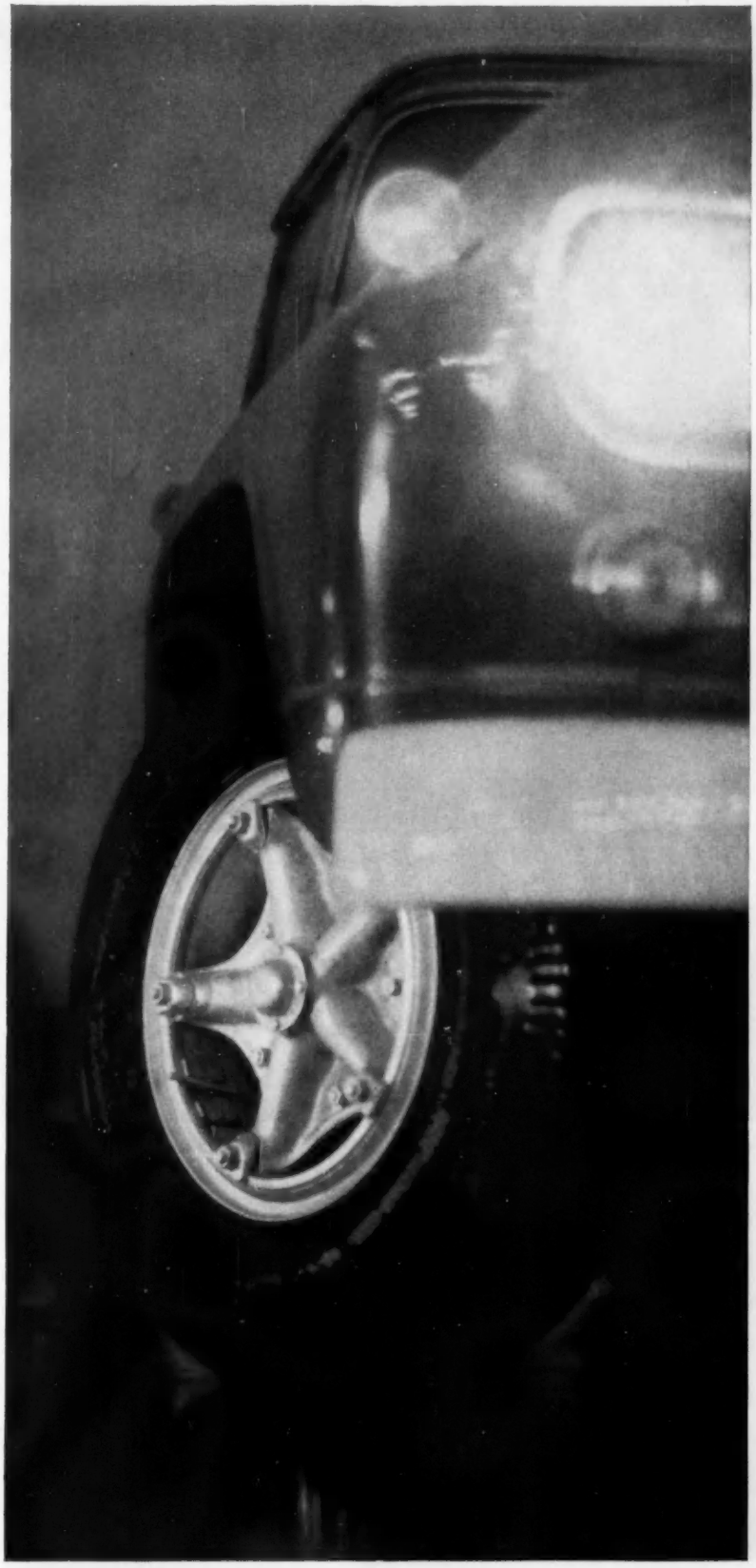
Overdrive	.85
Direct	1.00
Low	1.24
Low-Low	2.22

FULLER TRANSMISSION DIVISION

EATON MANUFACTURING COMPANY

KALAMAZOO, MICHIGAN

Sales & Service: West. Dist. Branch, Oakland 6, Cal. • Southwest Dist. Office, Tulsa 3, Okla. • Automotive Products Co., Ltd., Brock House, Langham St., London W.1, England, European Rep.



when you think big think Kelsey-Hayes

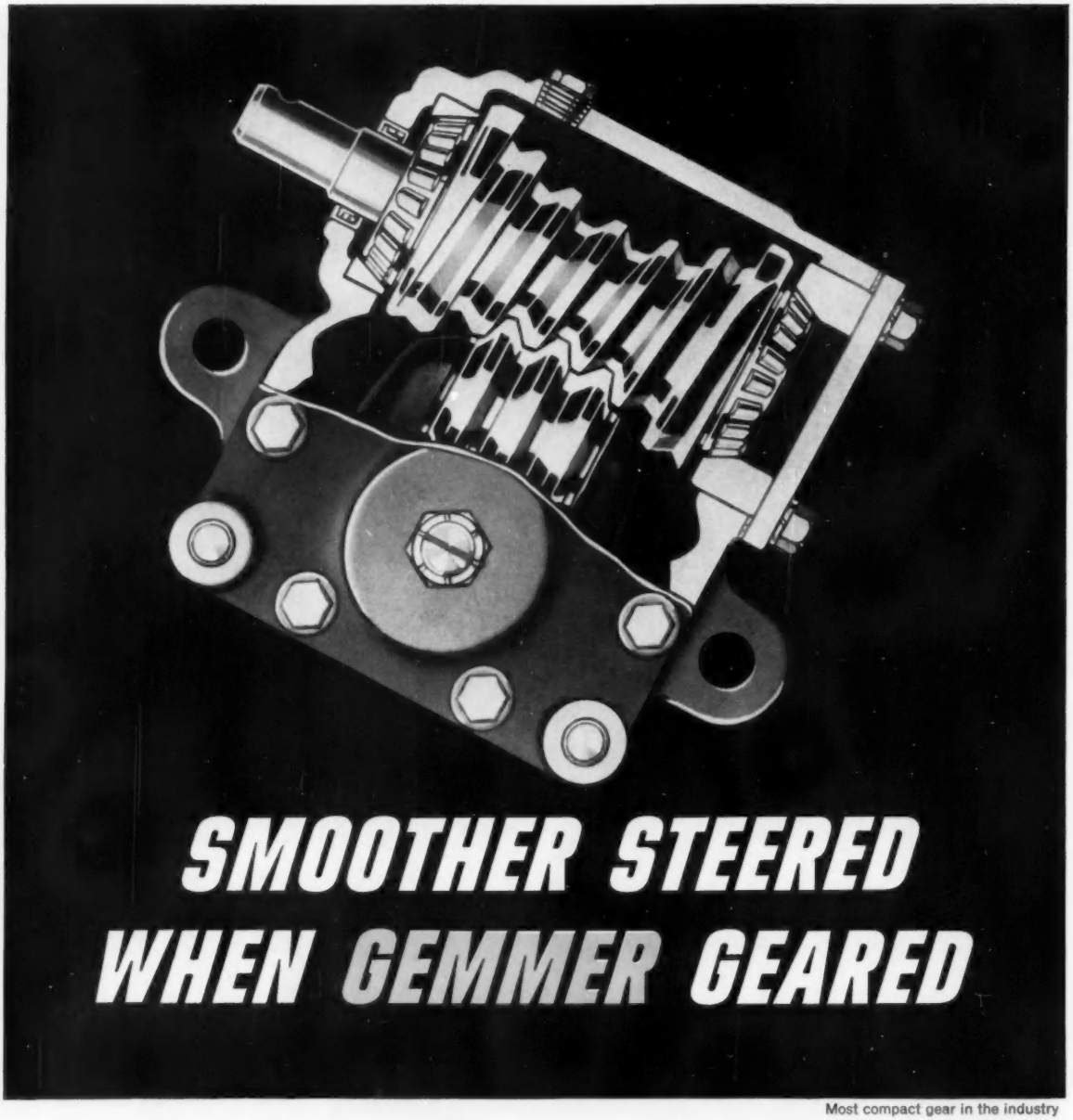
GUNITE a producer of industry's biggest truck and trailer wheels, is now a division of Kelsey-Hayes Company. Formerly Gunite Foundries Corp., Rockford, Ill., Gunite is one of the oldest and most respected suppliers of cast steel wheels and heavy duty truck drums. Facilities and experience of this new division, combined with our own, now make it possible for us to supply industry with a complete range of truck wheels and drums. Kelsey-Hayes Company, Detroit, Michigan.

KELSEY HAYES COMPANY

World's largest producer of automotive wheels, hubs and drums

OPERATIONAL PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; **Rockford, Illinois;** *Windsor, Ontario, Canada.*

K H



SMOOTHER STEERED WHEN GEMMER GEARED

Most compact gear in the industry

Gemmer steering is engineered for strength and ease of operation . . . built for lifetime service and minimum maintenance. Customer pleasing features of the 7D gear are:

Compactness . . . High numerical ratio of 28:1 . . . An efficient, rugged gear . . . Simplicity of installation and adjustment . . . Available in either malleable or aluminum housings

For *your* steering needs, Gemmer offers you experience as old as the industry.

Gemmer steering
SINCE 1906

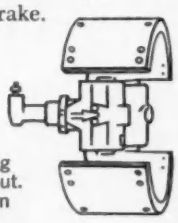
ROSS GEAR AND TOOL COMPANY, INC.

Gemmer Division, Detroit, Michigan • Ross Division, Lafayette, Indiana

ACTUAL TESTS PROVE:

NEW STOPMASTER BRAKE IS the most advanced brake design in 30 years!

Over three years of thorough and demanding road tests have proven the superiority of the new Rockwell-Standard Stopmaster Brake. Of its many new improvements the Stopmaster incorporates these major advantages to meet the modern trucking industry's demand for a more efficient, more dependable brake.

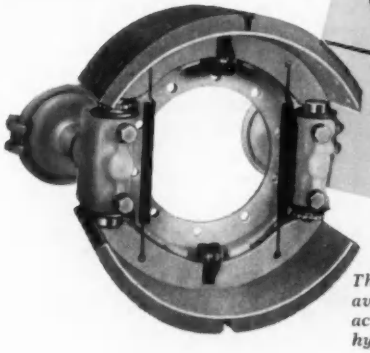


New Stopmaster actuation principal results in higher braking efficiency with less input. In dual actuation design both shoes do an equal amount of work over the entire lining surface. This balanced shoe action assures more dependable service; faster, surer stops; less maintenance.

New Stopmaster 15" diameter permits increased air circulation between brake drum and wheel rim. This results in cooler operating temperatures . . . less heat fade, longer lining life, longer drum life. Smaller diameter means less weight.

AVERAGE RESULTS OF NUMEROUS HIGHWAY VEHICLE TESTS PROVE:

35% lighter weight..	more payload capacity!
38% less heat fade..	safer, more continuous operation!
57% less air volume required..	permits smaller air reservoir tanks!
56% longer lining life..	lower operating cost, less maintenance!
56% longer drum life..	more dependability, less downtime!
66% less adjustment required..	greater safety, reduced maintenance!
37% less service parts	smaller inventories, less expensive!



The Stopmaster 15" Brake is available with either air or hydraulic actuation . . . also up to 30" diameter, with hydraulic actuation for heavy-duty, off-highway vehicles.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

Brake Division, Ashtabula, Ohio

a fel-pro gasket
progress report

new FEL-CoPRENE

new rubber gasket for cylinder head covers—solves seepage problem—has dimensional stability for perfect fit

Seepage problems resulting from improper fit, or improper resistance to fluids can be solved by the exceptional dimensional stability, conformability and sealing capacity of FEL-CoPRENE, Fel-Pro's new special formula rubber compound. Problems of size change or breakage that often occur with conventional materials are eliminated. FEL-CoPRENE fits right every time—even after months of storage. Actually costs less to use because it eliminates costly returns, needless replacements and installation problems.

FEL-CoPRENE has greater resistance to high pressure and temperatures—will not stick or tear even after prolonged high temperature operation—comes off cleanly and in one piece, and FEL-Co-PRENE is not affected by oils or mild solvents. FEL-CoPRENE is the low-cost, high-performance choice for many other applications such as: Push Rods, etc., on both diesel and gasoline engines. The exceptional resilience of FEL-CoPRENE gives it better conformability for irregular surfaces particularly common to stampings.

Information concerning production samples and complete technical data is available on request. Send us your specifications and requirements for recommendations and advantageous quotes.

FEL-PRO maintains a complete engineering service to supply your gasket needs. Write for a copy of our complete gasket material selector catalog. Felt Products Mfg. Co., 7450 N. McCormick Blvd., Skokie, Illinois.

In Detroit: 19932 Livernois Avenue
Phone: UNiversity 2-3522

FEL-PRO gaskets

FEL-PRO

gasket specialists
since 1918.

R-940D

Contributing to the miracle of modern car manufacture

SEALED POWER FACILITIES AND INGENUITY

Because modern car manufacture is so vastly complex, it is easy to overlook the operational scope of many of the industry's individual purveyors. The manufacture of piston rings which match your engineering requirements, for example, is an involved and costly process.

Yet, as important at Sealed Power as ring production and quality control, are the men and the facilities which so often allow us to come up with independent solutions to some of your knotty problems.

No one can top Sealed Power in service. To maintain this superiority, Sealed Power recently opened the piston ring industry's newest and finest research and technical center.

Historically Sealed Power has walked hand in hand with the reciprocating engine industry on the pathways of progress. We continue to dedicate all our abilities to our common cause.

Progress through Profits

Sealed Power Preferred Performance

PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • SEALING RINGS FOR ALL APPLICATIONS

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE • 7-236 GENERAL MOTORS BUILDING • PHONE TRINITY 1-3440

CHEVROLET CORVAIR

NEW SMALLER-SIZE CARS... GIANT-SIZE PERFORMANCE

...and Rochester-GM Carburetors deliver tailor-made economy and performance

Each of the newer-size General Motors cars has a power personality all its own. And Rochester-GM Carburetors have been individually designed and developed to fit the exact requirements of each car's engine. That means maximum performance and economy.

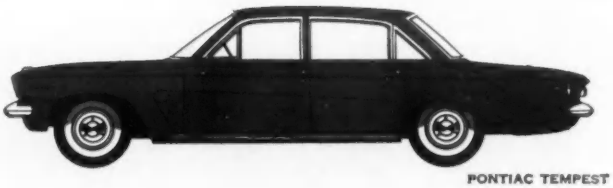
The success of this tremendous job was made possible through GM Reliability . . . the system of checks and counter-checks that becomes a vital part of each step in the development and manufacture of Rochester-GM Carburetors. Before these carburetors were released, they were subjected to thousands of torture-loaded miles . . . in the plant, on the GM Proving Grounds, and on the road . . . to insure their complete reliability.

Even now, field men are following through, sending back pertinent information that is immediately incorporated into current plans. The result: a carburetor that performs its job when it's asked to perform and for as long as it's expected to perform.

Rochester Products Division, General Motors Corporation, Rochester, New York.

BUICK SPECIAL

OLDS F-85



PONTIAC TEMPEST

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Rochester Reflects Reliability

GENERAL MOTORS

GM

America's number one original equipment carburetors

ROCHESTER CARBURETORS

GENERAL MOTORS

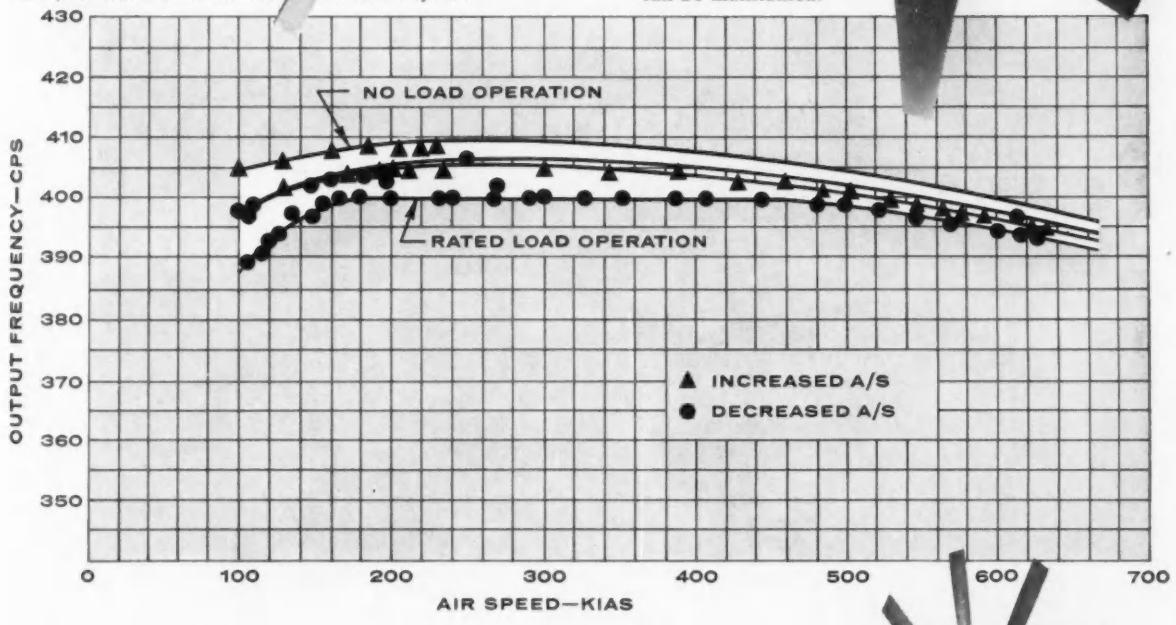
AiResearch ram air turbines unequalled in reliability and fine speed control

Electrical ram air turbine

In-flight hydraulic and electrical power for aircraft emergency use and airborne pods is supplied by AiResearch ram air turbines ranging in size from fractional to 100 horsepower. The fine speed control regulates the turbine to ± 5 per cent from aircraft design speed to above Mach 1. For special electrical applications frequency control lower than ± 5 per cent can be maintained.

Hydraulic ram air turbine

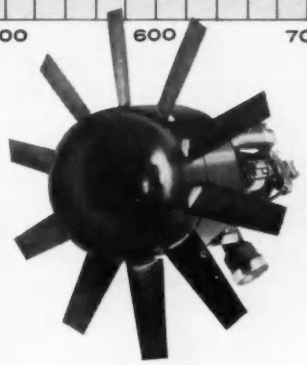
Fine speed control of 2.5 KVA ram air turbine system



As an emergency power source, the ram air turbine provides sufficient hydraulic power, electrical power or a combination of both for operation of the aircraft's basic controls in the event of main engine failure.

Ram air turbines also serve as auxiliary power supply systems, particularly in remote locations where independent power supplies offer optimized design. For example, they supply continuous electrical power to operate electronic equipment within aircraft-carried pods. Other areas of ram air turbine application include high speed drones and STOL aircraft.

AiResearch produced the first successful ram air turbine and has delivered more than 6000 units in 20 model types — more units than any other company. This knowledge and experience not only contribute to the reliability and high performance characteristics of AiResearch ram air turbines but also enable the company to produce newly designed units in the shortest possible time.



Hydraulic ram air turbine

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THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

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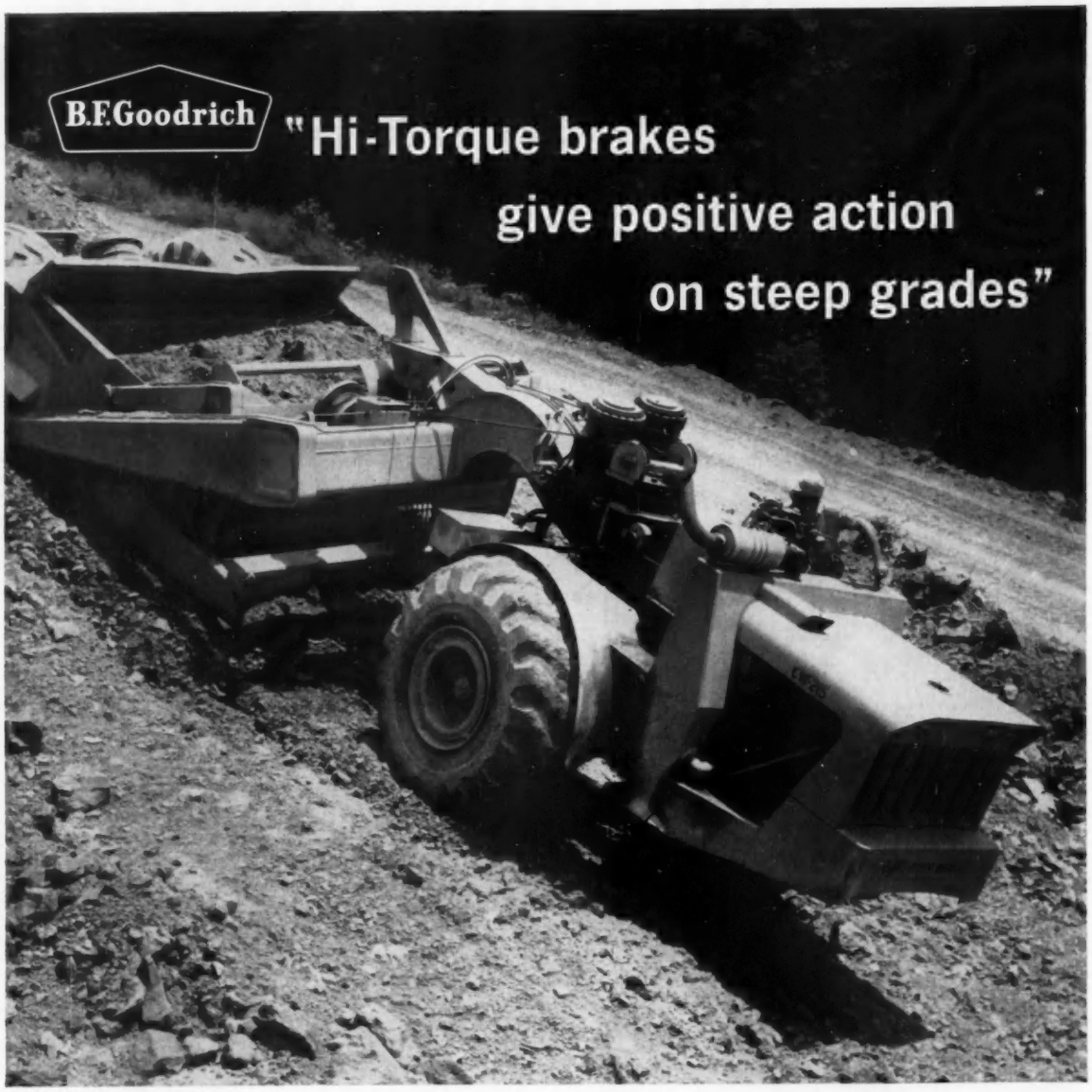
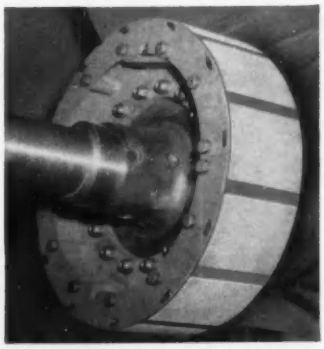


This Curtiss-Wright earthmover, equipped with B.F.Goodrich Hi-Torque brakes, is operated over rough West Virginia terrain where brakes must be applied frequently. The contractor reports "positive braking action on steep grades is the outstanding Hi-Torque feature." Gross weight on this vehicle is 52 tons, with payload varying from 44,000 to 50,000 pounds.

Hi-Torque brakes give heavyweight vehicles adequate safety and controllability—stop vehicles in approximately half the distance required for conventional two-shoe brakes. With this reserve braking power, cycle time can be reduced as equipment is operated in higher gear. Operators can tackle grades usually considered unsafe, since Hi-Torque brakes don't fade, will stop a fully loaded vehicle downhill!

You can use these brakes in *your* heavy-duty vehicles with a minimum of design change. Available in seven basic sizes; operation air-over-hydraulic, or direct hydraulic. For complete information call or write *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. SJ-2, Troy, Ohio.*



Full circle contact with drum is provided by Hi-Torque brakes giving maximum effective braking surface in the same size unit. Hi-Torque stops vehicles twice as fast as conventional brakes.

B.F.Goodrich Hi-Torque brakes

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Torque Converter

- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
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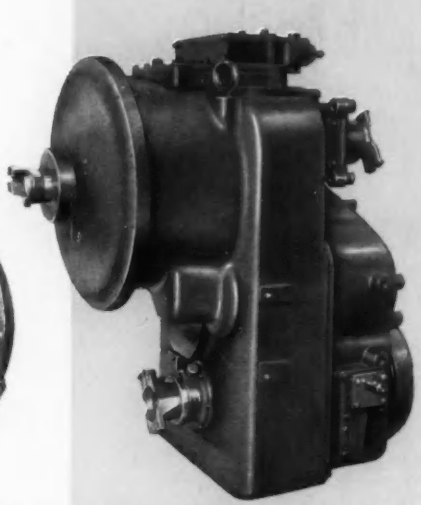

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Power Shift Transmissions and Torque Converters

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless – even with heaviest loads.

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With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.

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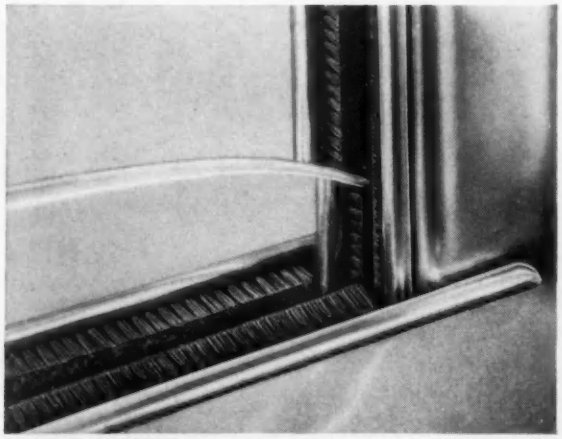
The pile must hug the surface of the glass tightly, flexing with every movement of the window. And Schlegel pile, because of its *natural resilience*, keeps the seal consistently tight to shut out rain, wind, dust and noise.

Natural resilience. It comes from a balanced blend of fibers. Schlegel woven pile can be supplied in the most resilient grade to eliminate your specific problems.

It's a dense pile. It holds the glass firmly in place to prevent rattles. The pile will stay uniformly dense through years of wear, because we interlock each tuft of yarn into a woven fabric backing.

You can get Schlegel woven pile in the type of glass run channel or belt strip you need. Specify Schlegel pile—favorite of the industry since glass windows were first used in cars.



Glass moves friction-free and is weathertight in this glass run channel with resilient Schlegel woven pile liners.

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Diesel or carbureted interchangeability presents no problem for Failing engineers, and it gives them a plus feature they can pass along to the customer. There are other benefits, too. "The wide range of power sizes in the International line lets us use IH engines for many of our new models," says Research Engineer Herschel Bules shown here, at left, with Mr. Carley.

Failing has been building portable drilling equipment for thirty years and their experience has shown that International's many fine features go far beyond the drawing board. In addition to engineering advantages, rugged International engines provide the steady, dependable power needed on heavy-duty drilling rigs. Customer reports from all over the world prove the reliable performance of IH-powered Failing equipment.

"The convertibility of either International gas or diesel power is a great asset. Similarity of mounting and accessories, and compact design further simplifies installation."

—EVERETT CARLEY, Chief Engineer,
GEORGE E. FAILING CO., Enid, Okla.

Here's an inspector on Failing's assembly line checking final installation of 75-hp carbureted engine. International carbureted engines are available in a variety of models, for gasoline, LP gas, natural gas or combinations. The UC-221 above, has the same rugged construction as its diesel twin shown at the right.

Interchangeable in size and power, the UD-236 is installed for customers who specify diesel operation. There are 35 engines in the International line—16.8 to 385 max. hp. Stripped engines or complete power units are available, and factory-made accessories and attachments further extend International flexibility.

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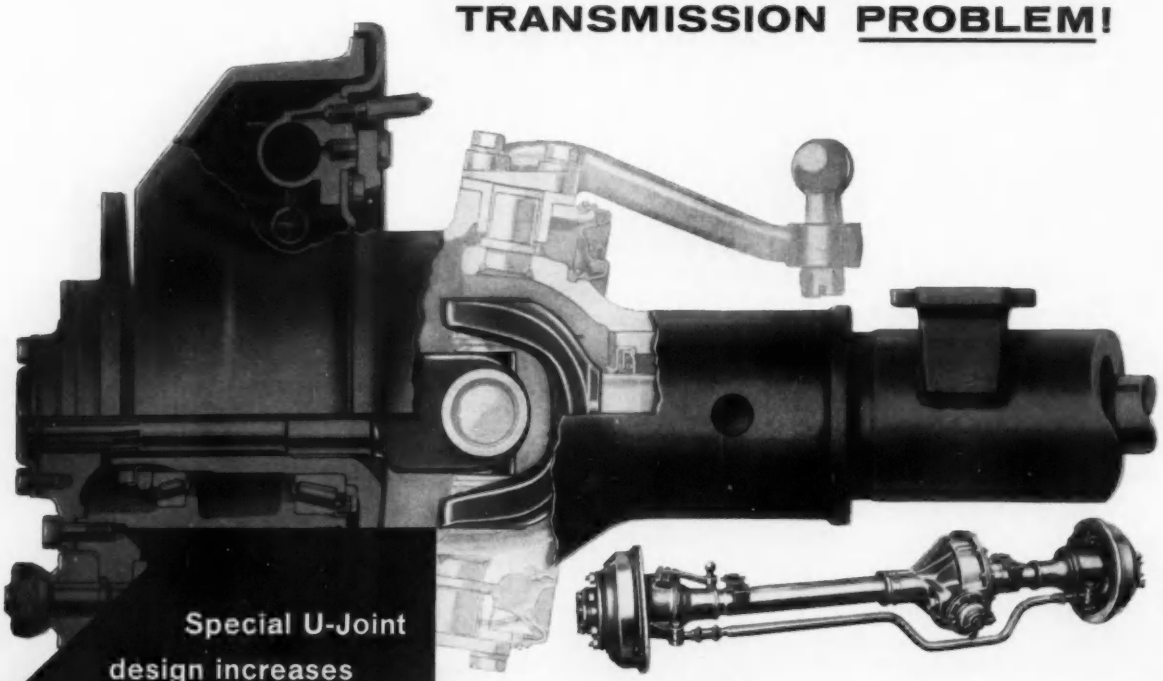

Special U-Joint design increases axle torque capacity... yet lowers axle production costs!

Working with a major manufacturer of truck axles, Rockwell-Standard engineers developed a new design for a front steering, driving axle that uses a single carden universal joint in place of the expensive and complicated constant velocity type previously used on a special all-wheel-drive vehicle.

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Whether you are designing a new product or seeking to improve an existing one, consult Rockwell-Standard engineers for specialized help in meeting your universal joint needs. Chances are, a Blood Brothers product will not only increase performance – but save you time and money as well.

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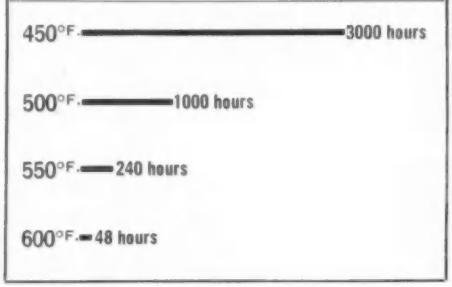
VITON can handle tough design problems that result from higher operating temperatures and recently developed fuels and lubricants. Current and potential applications of VITON include valve stem seals, carburetor pump cups and needle valve tips, speedometer pinion seals, transmission front pump seals, diaphragms, rear axle pinion seals, power steering hose tubes. For additional information, contact your rubber supplier or write for AN INDUSTRIAL REPORT ON VITON. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE-2, Wilmington 98, Delaware.

VITON: OUTSTANDING HEAT RESISTANCE



VITON: OUTSTANDING FLUID RESISTANCE

Data obtained by immersing VITON vulcanizates for 7 days and measuring the effect on properties shown.	Tensile strength, % retained	Elongation, % retained	Volume swell, % increase	Hardness change, points
Fuels:				
Ref. Fuel (70 isooctane, 30 toluene) @ 75° F.	93	100	2.5	+1
JP-5 petroleum aircraft fuel . . . @ 75° F.	100	100	0.4	+1
Automatic Transmission Fluid . @ 350° F.	95	95	1.9	0
Rear Axle Oil . . . . . @ 350° F.	95	100	9.1	+2
Combination Transmission and Rear Axle Oil . . . . @ 350° F.	80	89	1.5	0

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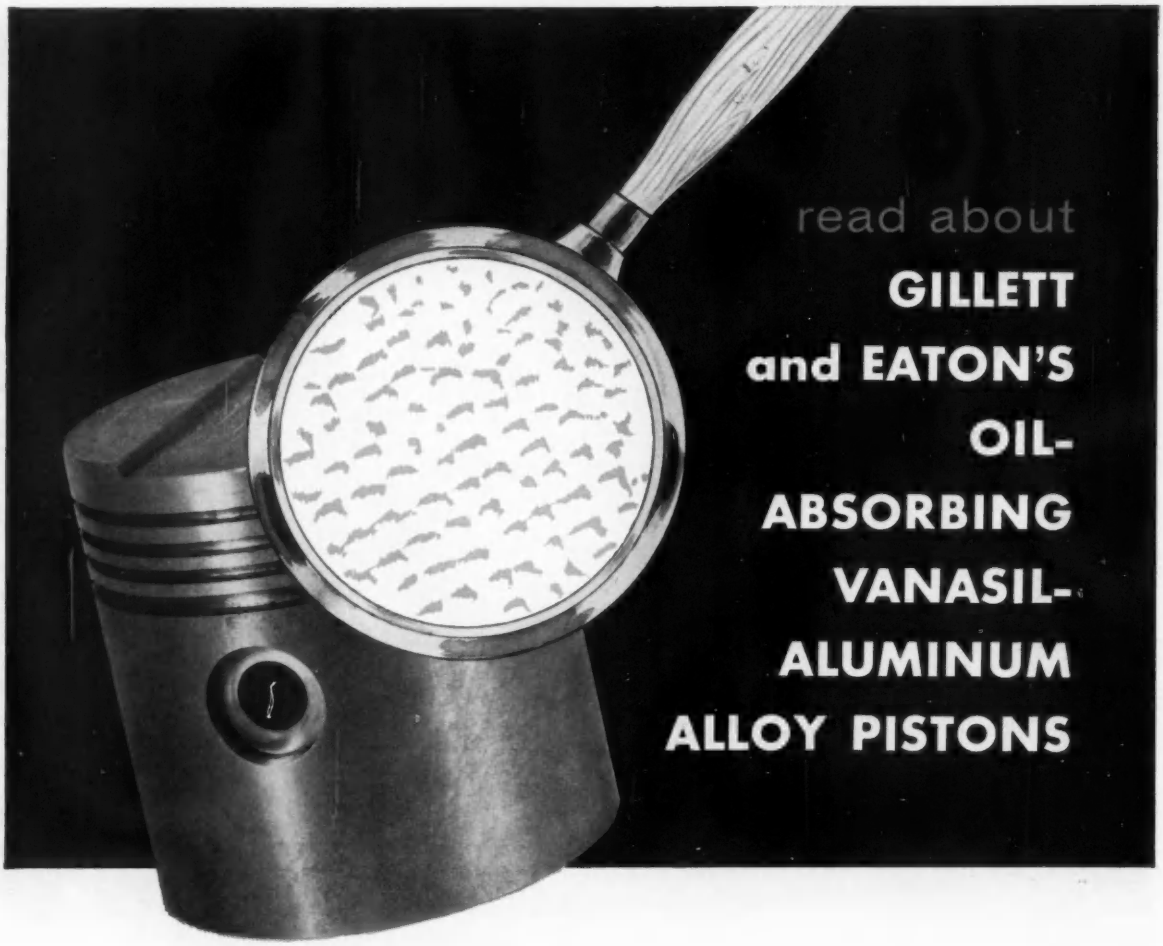

METALLURGISTS have tested piston metals from strong (but heavy) iron to light (but soft) aluminum. From all the alloys in between, they have found only one with all the properties ideal for pistons.

This one unique alloy combines the strength of iron and the lightness of aluminum. Oil absorbing Vanasil, is a Hyper-eutectic silicon aluminum alloy, and is manufactured exclusively by Gillett & Eaton, Inc.

A high silicon-to-aluminum ratio is precisely maintained to make Vanasil 30% harder than ordinary piston aluminum, and in addition increases "hot strength". Diesel trucks have repeatedly run over 200,000 miles with under .005″ wear in the top ring groove of Vansil pistons—reducing wear up to 75% at this vital point.

When Vanasil solidifies in casting, the molecular structure changes into hard, inter-locking crystals. It becomes amazingly porous. In operation, the microscopic pores absorb oil from the fuel or lubrication system.

Saturated with oil, lubricity of the pistons is increased so that they require less energy and fuel to deliver full rated power. Should the lubrication system fail, Vanasil pistons retain enough oil to bring the engine to a safe stop.

Light weight and the increased freedom from friction of oil-absorbing Vansil pistons has in many cases increased engine power up to 25%. Why not find out if these long-wearing pistons can increase the performance of your engines? Write for specifications and test data.

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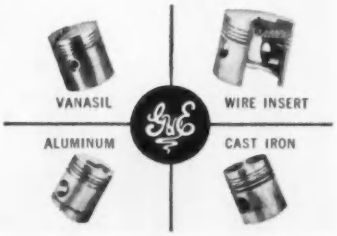

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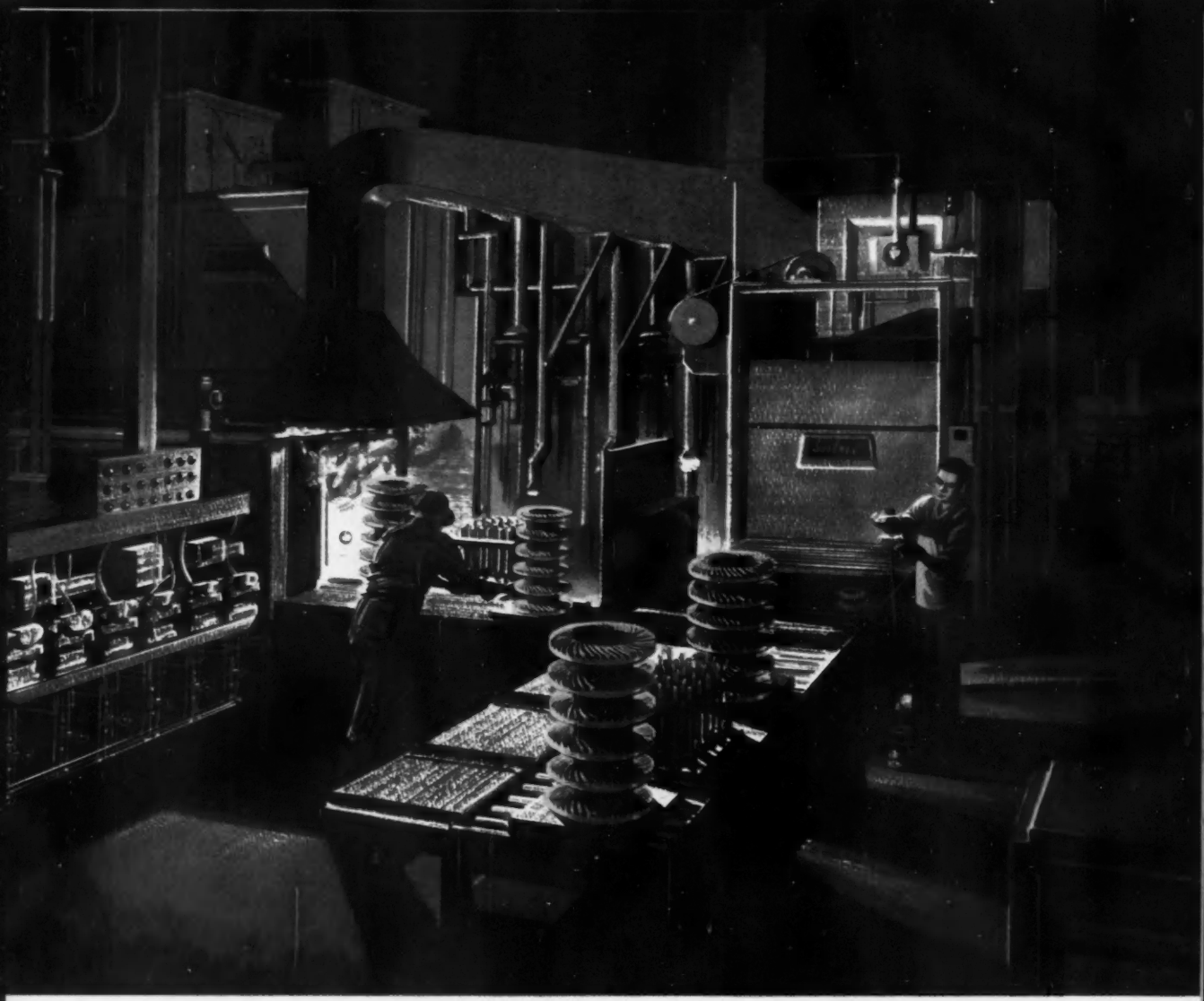

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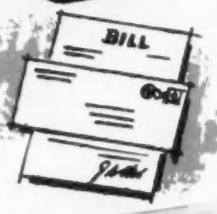

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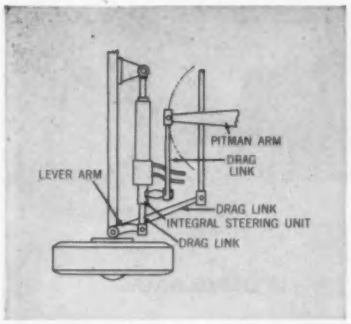
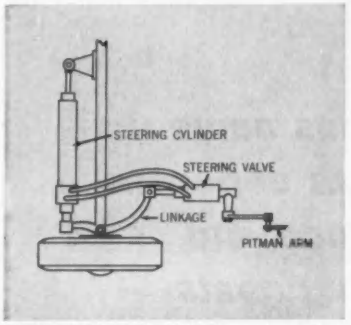
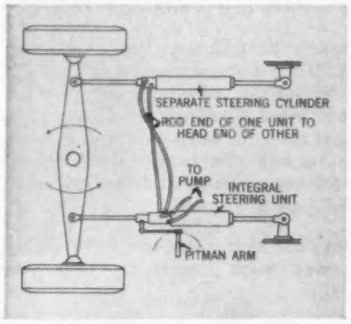


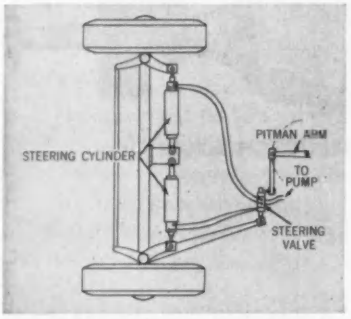
INTEGRAL LINKAGE system combines servo valve and steering cylinder with rod end fastened to frame and valve end to drag link.



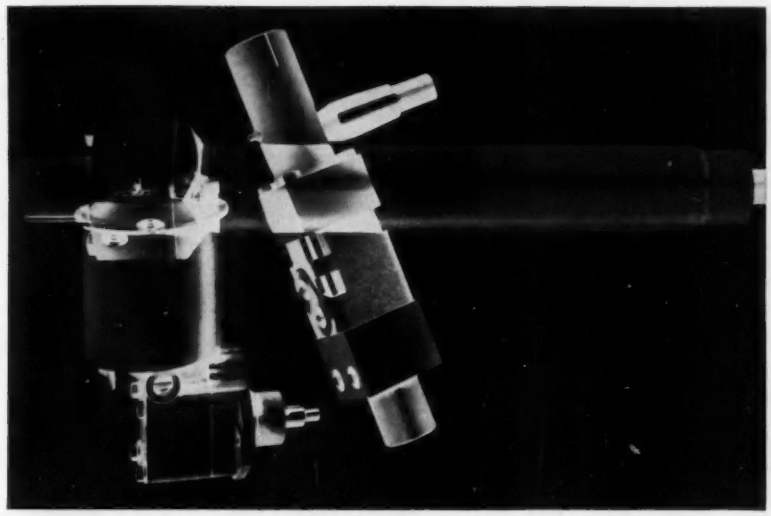
REMOTE LINKAGE system has separate servo valve and cylinder. Servo is mounted at most convenient point with cylinder located for maximum thrust.



COMBINED INTEGRAL-REMOTE system servo valve controls both cylinders. When integral unit (bottom) extends, remote unit (top) retracts.



REMOTE DUAL system uses one remote servo valve, offers best possible thrust conditions plus considerable installation flexibility.



FOR AXLE LOADINGS 1500—128,000 LBS.

New VICKERS. power steering systems use standard units, offer custom performance

Performance benefits normally associated with custom designs plus the economy of standard, production-built components are combined in new Vickers power steering systems. The cylinder, servo valve, and pump—key elements in the power steering system—are always perfectly matched to system needs because Vickers builds the *complete system*.

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Operating Economy—Systems are designed for high pressure operation (to 2000 psi) permitting smaller pumps, lines, reservoirs, valves and cylinders to be used. Further economy results because each basic size of steering unit is capable of a wide range of axle loadings. This permits some manufacturers to use a single size of steering unit for their complete line of vehicles. For example, in a single cylinder installation, the Model SC-26 cylinder can be used for any axle loading from 16,000 to 64,000 lbs.

Further economy over the life of the system results from the minimum number of moving parts required by this design and from its rugged construction. All cylinders are double walled to eliminate the common hazard of functional damage to cylinder walls from flying debris. Exclusive design vane pumps last longer, permit easy cold weather starting because pumping doesn't begin until after engine fires and comes up to speed.

Complete Responsibility — Both the equipment builder and ultimate user benefit because Vickers designs and builds all system components. In addition, a staff of power steering specialists is available to work with customers on specific development and application problems.

When equipment is being built for the export market, worldwide stocks and complete interchangeability of all parts made in Vickers plants throughout the free world offer added benefits.

More Data — Design advantages, dimensions, ratings, and other data are available in Bulletin titled "New Complete Power Steering Systems." Write for this 20 page Bulletin M5110.

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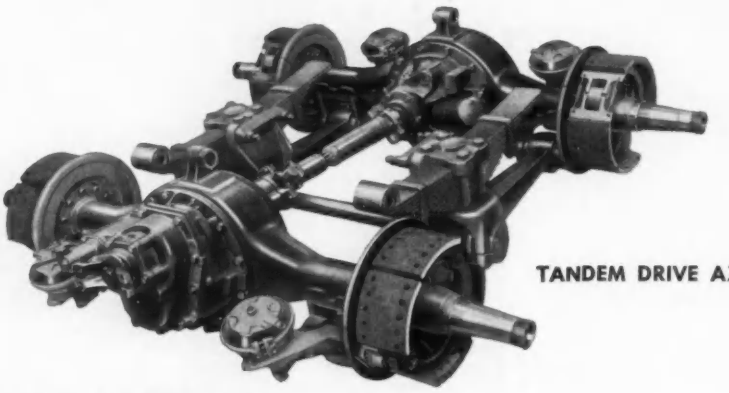

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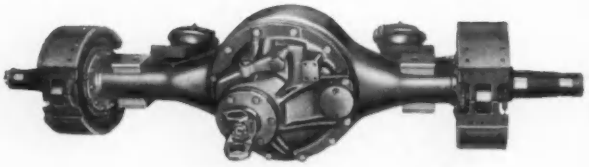

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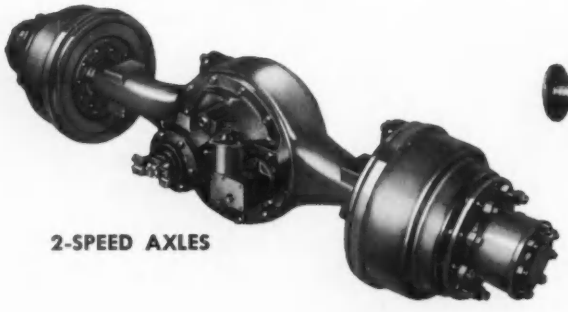

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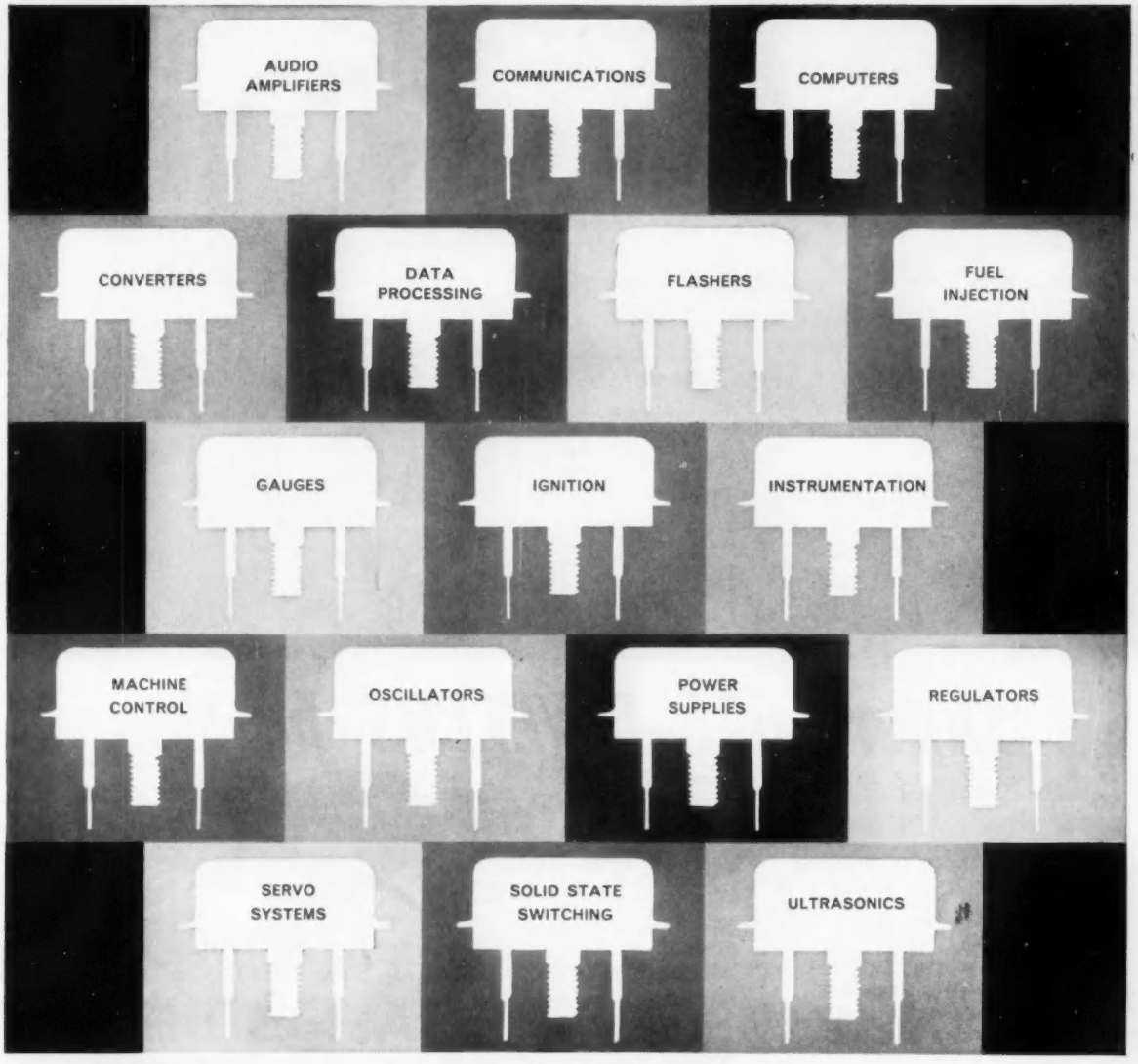

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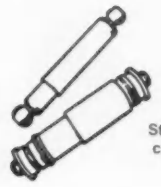

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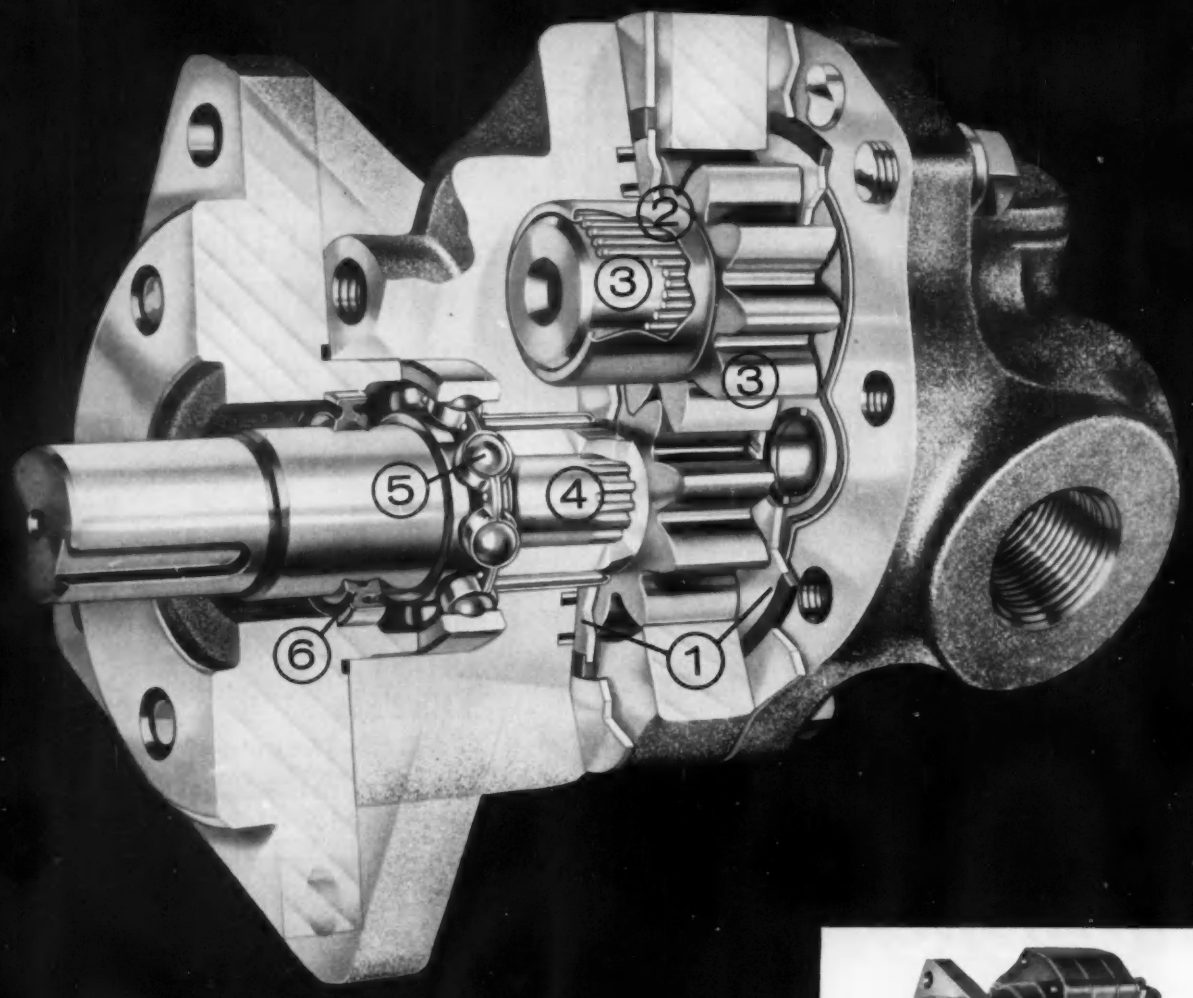

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We cut this new JE series pump in half to show you why Webster design tops competition in overall efficiency. Specifically, the JE saves horsepower, slashes operating costs, delivers dependable and trouble-free service.

It's the result of this combination of advanced features. . . . (1) pressure-balanced wear plates for high volumetric efficiency and to prevent clearance changes due to heat; (2) needle bearings for power-saving, anti-friction operation; (3) one piece gear and bearing journal units to assure minimum deflection and proper alignment on both drive and idler assembly; (4) free-floating internal spline drives to eliminate key failures; (5) thrust bearing on drive shaft to absorb compound driving thrusts; (6) double lip seal on drive shaft for added protection against seal failure and dirt.

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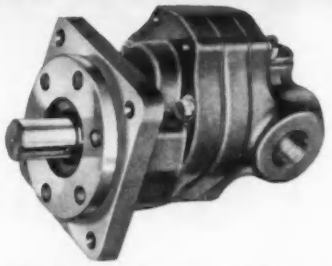

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Capacity: 10 sizes — 5 to 40 gpm
Pressures: to 2000 psi
Operating Speeds: to 2400 rpm
Porting: side (std.) end (opt.)
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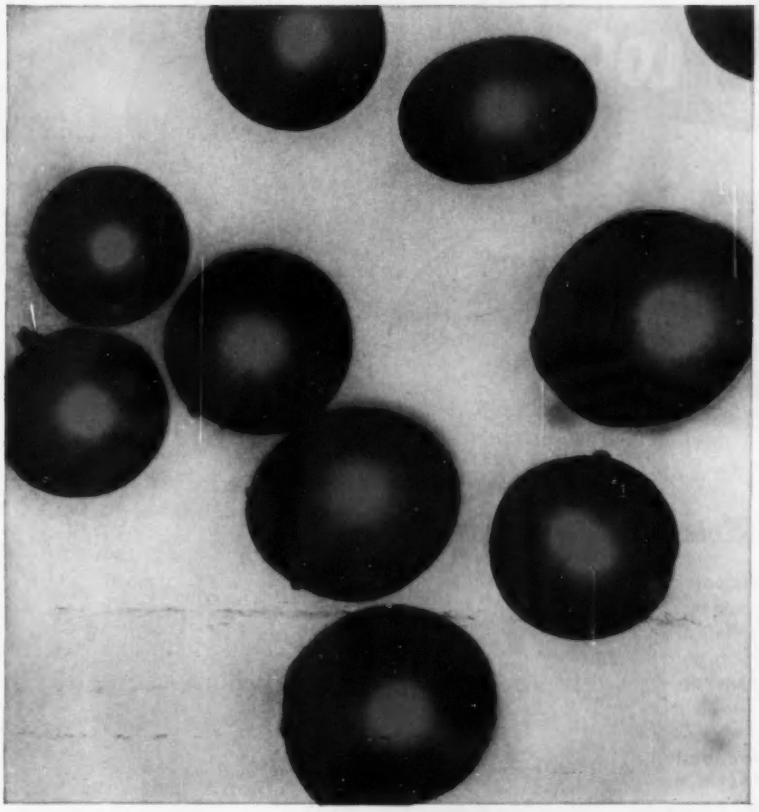

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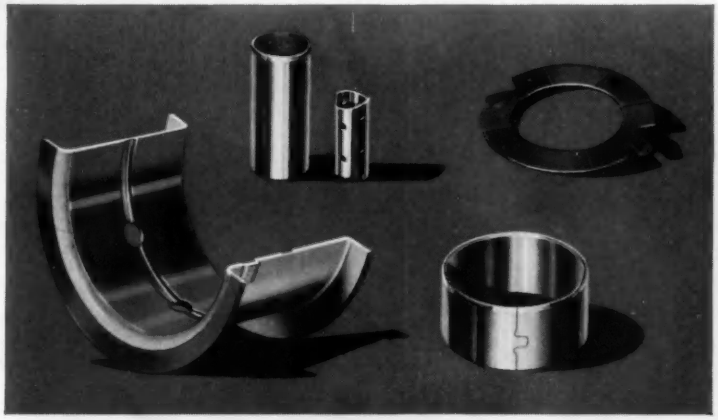

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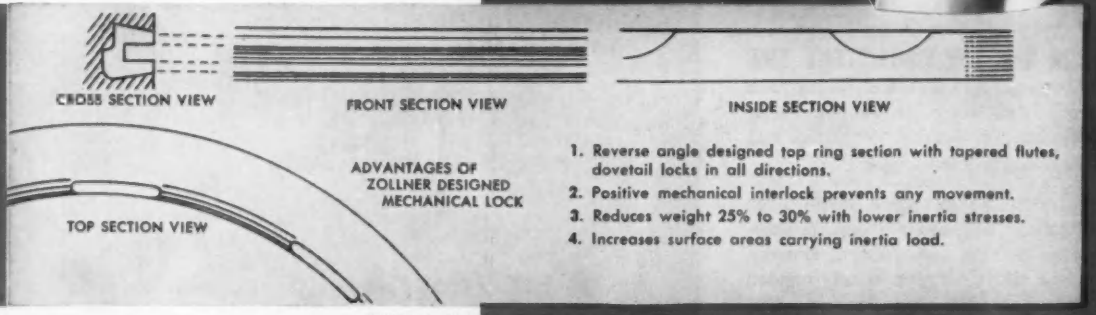

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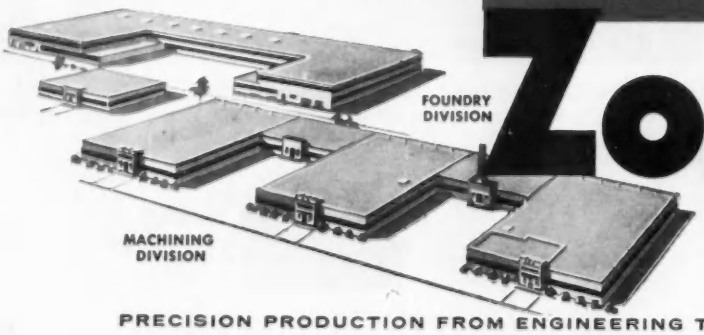

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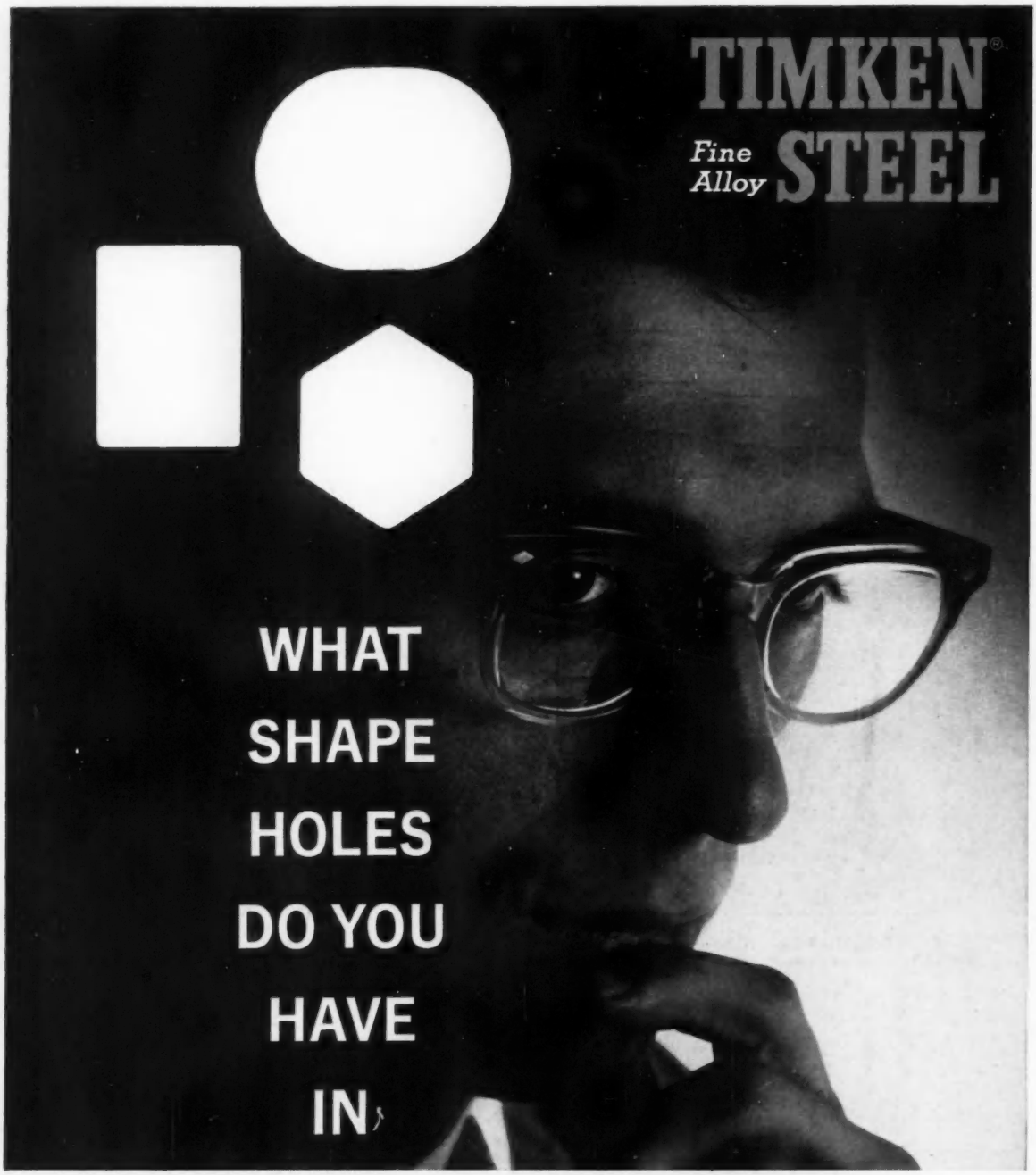

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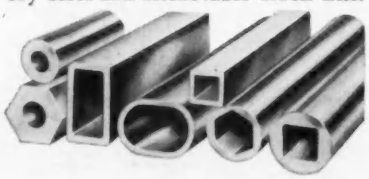
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